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# STUDIES ON THE INSECT FAUNA OF IOWA PRAIRIES

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## INTRODUCTION

Seven-eighths of the area of the State of Iowa was once covered with prairie (Shimek, 1911). But most of the native prairie has rapidly disappeared before the army of homebuilders. The remaining prairie is restricted largely to railroad rights-of-way, roadsides, rural school grounds and State Parks. A few privately owned larger areas whose roughness, poor soil, or drainage problems have saved them from the breaking plow, exhibit typical prairie flora. The poorly drained tracts realize such net profits to their owners, that it seems practical in many cases to leave them in permanent meadows for hay. The rough land is generally pastured, but in most cases not heavily. Many smaller patches of prairie flora along railroad rights-of-way, roadsides and on rural school grounds will probably persist for a long time. The State Park plans show provision for the retention of natural conditions, and will probably be expanded before long to include more extensive areas of native grassland.

The small amount of prairie which remains presents insect problems which are worthy of study. Children of the rural schools meet with numbers of prairie insects on their way to school and on the school grounds. The rural teachers are in need of assistance in the determination of these insects, whose interesting habits are observed by the pupils. Every year these areas of native vegetation show some centers of breeding increased numbers of certain insect pests, which spread out and infest neighboring cultivated crops. These virgin tracts are of great interest and value to the collector and taxonomist who find these places accessible for the collection and observation of many species. Ecological and physiological studies with the insects and the original flora, may furnish data and principles for comparative study in the probable distribution and the control of injurious insects. Because of the general interest to all of its citizens in the original conditions of a state, records of the fauna of native prairie at various intervals of time add to the history of the state. These needs and interests suggested that a general survey of the insect fauna of some of the larger tracts of prairie in the several parts of Iowa, together with the associations of the species with plant communities, would be of value.

## REVIEW OF LITERATURE

Earlier investigators have supplied us with several lists of species of the major orders of insects of Iowa. Lists of the insect fauna of a few counties have been published. A large number of papers have dealt with the life histories and habits of insects of the state. But the attention of the author has not been directed to any detailed associational study of the insect fauna of Iowa prairies.

Allen (1871) dealt with associational distribution of the fauna of prairies in a general way. Concerning insects he wrote: "The insect fauna presents peculiarities similar to those of the flora, on which their existence is so intimately depended. Certain groups are represented in an unusual variety of species and abundance of individuals, but the most numerous forms are often exceedingly localized. Other groups are again but sparsely represented. No country, however, it is to be hoped, is richer in Orthoptera (grasshoppers), either in species or individuals; and a few species of butterflies are also especially numerous, of which a small portion seems to be strictly prairie forms. The Hemiptera and Neuroptera exist in great abundance, the dragon flies being richly represented, both as respects the number of species and the gorgeousness of their colors, many of which are never or rarely seen in the Atlantic States. The Hymenoptera, on the other hand, are comparatively few, especially the bees and wasps, notwithstanding the abundance of the flowers. If the Diptera, however, do not make up the equilibrium, it is not because mosquitoes and blood-sucking flies (Tabanidae) are deficient either in variety of species, in number of individuals, in size or in voracity."

Brumfiel (1919), on the rolling prairies of Johnson county, Iowa, found "the highly specialized orders of Hymenoptera, Diptera, Lepidoptera and Coleoptera were abundant" in species and numbers, and on the sand-dune prairies of the same county that the "Tiger beetles and digger wasps . . . " were the most common invertebrates.

The prairie fauna of the neighboring state of Illinois has been studied quite intensively in recent years. Shelford (1913) surveyed the prairie communities in the region about Chicago. He listed 56 species of insects from low prairie and temporary marshes, and 31 species from compass-plant *(Silphium)* prairie. Vestal (1913) found 350 species of animals on sand prairie and grouped them with several plant communities. Adams (1915) extended his studies over several types of prairie in several parts of the state. He listed 130 species of prairie insects, and through reference to previous literature and through his own observations, showed that many of these insects are associated with the grasslands. However, his lists of characteristic insects of each of several plant communities are small. Shackleford (1929) made quantitative studies of several plant communities of Illinois prairie, and has given names to two animal communities. For the animal community associated with the *Andropogon* associes of plants she has originated the name of *Lygas-Formica-Microtus* Prescocies. To the animal community associated with the low prairie *(Carex* and *Salix longifolia)* the name of *Cambarus-Eucrangonyx* Presocies was given. Approximately 150 animals were taken as members of each Prescocies, and about 100 of these in each case are insects.

For Kansas, Hayes (1927) stated that "the Hemiptera, represented by such abundant species as the tarnished plant-bug (*Lygus pratensis* Linn.) and other leaf and plant bugs, is perhaps the predominant order of insects of the prairie." He found the scavenger group of insects to be one of the interesting groups. The seasonal abundance of the chinch-bug in prairie grasses attracted his attention. Whelan (1927) surveyed the winter fauna of species of bunch grass (*Andropogon* spp.) of eastern Kansas and found that *Collembola* composed about 25 per cent of the animal life, while chinch bugs were greater in number than any other species, as they constituted about 35 per cent, 7 per cent of these being dead. The ants composed 4 per cent, the click beetles 2 per cent and the snout beetles 1 per cent. Of the remaining per cent, most of the insects were contained in the two orders *Hemiptera* and *Coleoptera*. After a brief discussion on the economic relations of these insects the following conclusion was made, "From the above data, however, we conclude that if the inhabitants of the bunch-grasses were all killed when their hibernating places were burned, there can be little doubt but that many more injurious insects than beneficial ones would be killed."

## COLLECTING STATIONS

The author's study of the prairie began several years ago with the flora and the types of native grasslands in the state. The following outline of the general types of the prairie of Iowa by Shimek (1911), which came into the hands of the author early in his work, suggested places for investigation. "The areas which were originally covered with prairie flora are divided into these six more or less distinct types:

1. The broad, flat plains which characterized the Wisconsin and Iowa drift areas and a part of the uneroded Kansan drift area such as may be observed in Osceola county and southward.
2. The more rolling drift surfaces are presented by the greater part of the Kansan area and the more or less distinct moraines bordering the Wisconsin and Iowa areas.
3. The very rough loess ridges which border the Missouri valley and which present the most extreme xerophytic conditions in Iowa. Similar conditions are found in the rough Wisconsin morainic (?) region in southwestern Lyon county, and the floras of the two areas are practically identical.
4. The well-drained alluvial plains such as are shown at their best along the Missouri, but which are more or less developed along all streams.
5. The prairie ridges which appear in all the forested rougher parts of the state, but are most striking in the more heavily timbered eastern parts where they have been known as 'oak openings' because the surrounding forest, consisting largely of oaks, encroached upon them.
6. The sand-dune areas. These are usually considered distinct from the prairie, but a comparison of the floras shows that they differ very little."

The knowledge of exact locations of tracts of virgin land came from various sources other than the author's personal observations. Several extension service and research workers of Iowa State College furnished approximate information. In several instances conversations with older settlers in a number of communities aided materially. Bankers in several smaller towns of central and northern Iowa were able to direct the author to some of the best tracts. More than one hundred tracts varying in size from one to several thousand acres were seen. These areas were more numerous in the north, central and western parts of the state.

All of the observed areas showed evidence of disturbance. The western hillsides along the Missouri river were grazed, but only those which showed the least disturbance were studied. Most of the northern and central tracts were mown by September, yearly. Parts which showed the dominance of blue grass (*Poa pratensis* L.), of red top (*Agrostis alba* L.), or other marked disturbance at any season of the year, were not studied. Unmown smaller tracts were grazed at least during a part of the year.

The least disturbed prairie was seen 6 miles west and 1.75 miles north of Thompson. There, an area of one hundred and sixty acres with low hills and kettle holes showed little disturbance except along the south and west sides, where wagon traffic had brought about conditions that permitted blue grass (*Poa pratensis*) to gain some dominance.

The studies were made at forty different locations which exhibited varying communities of plants. When each area was reached, notes were taken on the plants in the portions from which insect collections were to be made. These notes listed the dominant grasses, and more common herbaceous plants with their relative abundance. Most of the plants were identified in the field and the scientific names according to Gray (1908) were used. Later the plant communities were classified according to a general plan outlined by Clements (1920). The following list of stations is fitted into the plan, and sub-divided to coincide with the centers of insect collection:

Grassland Climax (*Stipa—Bouteloua* Formation)

A. True Prairie (*Stipa—Koeleria* Association)

a. *Stipa spartea—Andropogon scoparius* association
Topography: hills, sides of hills
General location: central and northern Iowa
Stations:
Northeast of Iowa State College grounds
2 miles north of Ames
5 miles northwest of Buffalo Center
3.5 miles north of Ledyard
6 miles northwest of Ledyard
1.5 miles northeast of Ocheyedan
Ocheyedan Mound roadside
5 miles south of Stanhope
7.75 miles northwest of Thompson

b. *Andropogon scoparius—Bouteloua curtipendula* association
Topography: steep hillsides
General location: bluffs of Missouri and Big Sioux rivers
Stations:
4 miles northeast of Beloit
Council Bluffs
Gitchie Manito State Park
1 mile west of Hamburg State Park
1 mile north of Reels City
Sergeant Bluff
15 miles north of Sioux City
3 miles south of Westfield

1. Sub-climax prairie (*Andropogon* associes)

a. *Andropogon furcatus—Sorghastrum nutans* associes
Topography: hillsides near woods, river flood plains
General location: southeastern Iowa
Stations:
1 mile south of Amana
Lacey Keosauqua State Park
1.5 miles east of Muscatine
3 miles south of Muscatine

1 mile east of Verdi
6 miles south of Washington

b. *Andropogon furcatus—Spartina Michauxiana* associes

(1). *Andropogon furcatus* consocies
Topography: level, mostly wet meadow
General location: northern, central and western Iowa
Stations:
10 miles southwest of Ames
2.5 miles south of Ames
8 miles southeast of Britt
5 miles northwest of Buffalo Center
6 miles northwest of Cedar Falls
2 miles south of Ledyard
3.5 miles north of Ledyard
6 miles northwest of Ledyard
6 miles northwest of LeMars
5 miles east of Renwick
4 miles northwest of Thompson
7.75 miles northwest of Thompson

(2). *Spartina* consocies

Topography: low, level, wet, frequently with some standing water in spring, but not in summer
General location: several parts of the state
Stations:
2.5 miles north of Ames
2.5 miles south of Ames
1 mile south of Amana
Lake Amana shore
8 miles southeast of Britt
5 miles northwest of Buffalo Center
6 miles northwest of Cedar Falls
Gitchie Manito State Park
1 mile southeast of Gruver
2 miles southwest of Kelso
10 miles southwest of Kelso
4 miles north of Le Mars
3.5 miles north of Ledyard
6 miles northwest of Ledyard
.5 mile south of Missouri Valley
5 miles east of Renwick
4 miles northwest of Thompson
7.75 miles northwest of Thompson
6 miles south of Washington

(3). *Carex* socies

Topography: low, wet, often with standing water in the spring, but not in summer

General location: several parts of the state
Stations:
1 mile south of Amana
Lake Amana shore
2.5 miles north of Ames
2.5 miles south of Ames
8 miles southeast of Britt
5 miles northwest of Buffalo Center
6 miles northwest of Cedar Falls
3.5 miles north of Ledyard
4 miles northwest of Thompson
7.75 miles northwest of Thompson

(4). ***Polygonum amphibium*** socies
Topography: low, wet, with standing water in spring, but not in summer
General location: several parts of the state
Stations:
2.5 miles south of Ames
1 mile south of Amana
5 miles northwest of Buffalo Center
10 miles southwest of Kelso
3.5 miles north of Ledyard
.5 mile south of Missouri Valley
2 miles west of Pacific Junction
7.75 miles northwest of Thompson

B. Mixed Prairie (*Stipa—Bouteloua* association)

1. *Bouteloua hirsuta—B. curtipendula* association
Topography: gravelly hilltops
General location: central and northern Iowa
Stations:
2 miles north of Ames
Ocheyedan Mound
1.5 miles northeast of Ocheyedan
5 miles south of Stanhope

The list of plant communities is not complete. Only the more prevalent and conspicuous groupings were studied. The catalogue of grasses of Iowa by Pammel, Ball and Scribner (1903) aided the author in making and in checking his findings. The list of prairie flora by Shimek (1911), which shows the relative distribution and occurrence of several hundred species of plants on the several types of prairie, was of great service in checking the communities. Hayden (1919) recorded the floristic features of a prairie province in terms of ecological communities. This province, two miles north of Ames, was studied intensively by the author to partially guide his observations at other stations.

Some of the communities such as the *Bouteloua hirsuta—B. curtipendula* association and the *Stipa spartea—Andropogon scoparius* association were no longer extensive in area because of the general tillage and pasturage of such lands in the state. The communities on lower and rougher ground were more numerous and extensive. Other communities such as *Buchloe dactyloides—Bouteloua hirsuta* association of Gitchie-Manito State Park may occur, but they were not seen in tracts of sufficient extent to permit of the collection of typical insects from them.

## METHODS OF COLLECTING INSECTS

Several stations within one hour's driving distance of Ames were visited one to several times each week from about the first of March until November, or until mown in the later part of August, during the years 1925 to 1928, inclusive. At these stations basic collections were made at most of the plant communities of this study. Except at the most distant situations collections were made at other stations each month from May to October during one or more years. The extreme western and southeastern stations were visited during July and August of 1928.

Because an insect net was the chief means of collecting most of the specimens were adults. Larvae and nymphs occurring on the more common plants were brought in to be reared in the insectary, unless they could be readily recognized without rearing. From some of these immature stages a few parasitic insects were obtained. Some time was taken regularly at each station for the collection of insects on the ground. Stones and debris were frequently turned over in the search of specimens. Because permission from the owner of a tract usually carried with it admonition against digging up plants, little study was made of insects of the soil, except at the *Spartina* consocies near Gruver, where permission to dig was readily obtained.

In securing data concerning the host plants and inhabited communities, the larger groups of single species of plants and the several communities were collected from and observed separately. These separate collections were placed in individual killing bottles in the field and the numbers of the bottles were associated with notes on the plants. Later, when the insects were mounted, small numbers plus the locality labels served to key the data concerning plants with the insects.

Relative quantitative data were secured in several ways. At each sweeping a specimen of each different species was taken and prepared for permanent preservation until the author became acquainted with some of the widely distributed common forms. After that those forms were counted but not preserved unless a specimen showed some variation from the general appearance of the species. All specimens of rare species were saved. In this manner the insects of each community were secured in approximately correct relative ratios. The visits to several stations of each of the plant communities increased the number of species as well as aided in settling the questions of relative occurrence and most frequented communities of the various species. The general and extensive collecting made possible a survey of more communities in several parts of the state.

## DETERMINATION OF INSECT SPECIES

Except for a few commonly known insects, all determinations for the many families and orders of insects have been made by recognized specialists. Identification of specimens by comparison with those determined by specialists was attempted only in a few species. Many of the specimens will be turned over to the collection of the Department of Zoology and Entomology, Iowa State College. To increase the value of this survey, the services of specialists were sought and deemed requisite to thorough work. It became apparent to the author early in the problem that neatly mounted specimens with locality labels and in large series were appreciated by many specialists. The more extensive collecting brought out a few new species, which aided considerably in securing the services of specialists.

## ANNOTATED LIST

The following list furnishes the names of the species as given by the specialists whose names occur at the head of each order. The orders are arranged according to Comstock (1924). Within an order the species are arranged for the most part in accord with the most recent catalog of the order or some general list of insects. In several orders approximate positions of several species were secured from other sources, such as systematic papers and correspondence with specialists who determined the species in question. The chief work consulted in the arrangement of the species of an order is given at the head of the list of that order.

The plant community, or communities, at which each of the more generally distributed and numerous insect species occurred, is given with dates of the earliest and latest collections of adult forms. In the species which were observed or collected in less numbers, the dates and localities of collection are given. If the food habits of an insect were observed, the record occurs with the species in the list. When the number of individuals of a species taken or seen at a community was five or more during one season, the word common is applied frequently unless the number became so large that the word numerous could be used properly.

### ORDER COLLEMBOLA

The species were determined by Dr. J. W. Folsom. The arrangement follows Guthrie (1903).

*Orchesella ainsliei* Fol.

At *Andropogon furcatus* consocies under dead grass and moss, 2.5 mi. south of Ames, Sept. 22, 1928, two specimens.

*Isotoma viridis* Bour.

At *Andropogon furcatus* consocies under dead grass and moss, 2.5 mi. south of Ames, Sept. 22, 1928, one specimen.

*Entomobrya purpurascens* Pack.

At *Stipa spartea—Andropogon scoparius* association, under stones, 5 mi. south of Stanhope, Oct. 6, 1928. Numerous. At *Andropogon furcatus* consocies, under stone, 7.75 mi. northwest of Thompson, one specimen, Sept. 15, 1928.

*Lepidocyrtus cyaneus* Tull.

At *Andropogon furcatus* consocies, under stone, 7.75 mi. northwest of Thompson, Sept. 15, 1928, one specimen. At *Stipa spartea—Andropogon scoparius* association, under stone, 2 mi. north of Ames, Aug. 16, 1928, three specimens.

*Lepidocyrtus* sp.

At *Andropogon furcatus* consocies under stone, 7.75 mi. northwest of Thompson, Sept. 15, 1928, one specimen.

## ORDER ORTHOPTERA

The species were determined by Dr. B. B Fulton. The arrangement follows Blatchley (1920) and Scudder (1900).

*Litaneutria minor* ? Scudd.

One specimen, a nymph, at *Andropogon scoparius—Bouteloua curtipendula* association, Sergeant Bluff, July 26, 1928. A second nymph eluded capture. No others were seen.

*Diapheromera veliei* Walsh

At all *Andropogon* communities. Earliest adult, July 10, 1925. Latest adult, Sept. 19, 1928. Numerous in some places.

*Acrydium ornatum* Say

At *Andropogon furcatus—Spartina Michauxiana* associes. Earliest adult, March 25, 1928; latest adult, Sept. 15, 1928. Scattered over all of associes in spring. Restricted more to *Spartina* consocies after May 1, when temporary ponds had usually disappeared. The most common grouse locust.

*Paratettix cucullatus* Burm.

One adult specimen, May 30, 1926, 2.5 mi. south of Ames, at *Andropogon furcatus* consocies.

*Tettigidea lateralis parvipennis* Harr.

At *Andropogon furcatus—Spartina Michauxiana* associes. Earliest adult, March 23, 1926; latest adult, Aug. 14, 1926. Most numerous at *Spartina* consocies.

*Pseudopomala brachyptera* Scudd.

At *Andropogon scoparius—Bouteloua curtipendula* asscoiation stations from Gitchie Manito State Park to 1 mi. west of Hamburg State Park, July 24-30, 1928.

*Mermiria neomexicana* Thom.

One specimen, a nymph, at *Andropogon scoparius—Bouteloua curtipendula* association, July 31, 1928.

*Mermiria maculipennis macclungi* Rehn

At *Andropogon scoparius—Bouteloua curtipendula* association, 1 mi. north of Reels City to 1 mi. west of Hamburg State Park, July 30-Aug. 1, 1928.

*Eritettix simplex* Scudd.

At *Bouteloua hirsuta—B. curtipendula* association, 5 mi. south of Stanhope, April 25, May 9, 1928. The author (1928) records it from a *Stipa-Bouteloua* community.

*Orphulella speciosa* Scudd.

At all *Andropogon* communities. Earliest adult, July 7, 1928, 6 mi. northwest of Ledyard; latest adult, Sept. 19, 1928, 5 mi. south of Stanhope. Most numerous at *Andropogon furcatus* consocies and *Stipa spartea—Andropogon scoparius* association.

*Dichromorpha viridis* Scudd.

At *Spartina* consocies, Lake Amana, Aug. 12, 1927, 10 mi. southwest of Kelso, July 30, 1928, and Pacific Junction, July 31, 1928. Scarce.

*Chorthippus curtipennis* Harr.

At *Andropogon furcatus—Spartina Michauxiana* associes. Earliest adult, June 26, 1926; latest adult, Aug. 26, 1926. Most numerous at *Andropogon furcatus* consocies.

*Ageneotettix deorum* Scudd.

At all *Andropogon scoparius—Bouteloua curtipendula* association stations, July 24-Aug. 1, 1928. At *Bouteloua hirsuta—B. curtipendula* association, Ocheyedan Mound, July 23, 1928, and 2 mi. north of Ames, July 2-Aug. 7, 1926. Numerous at *Andropogon scoparius—Bouteloua curtipendula* association.

*Hadrotettix trifasciatus* Say

At *Andropogon scoparius—Bouteloua curtipendula* association, Sergeant Bluff, July 26, 1928, one specimen.

*Dissosteira carolina* Linn.

Seen along paths and at barren places at *Andropogon scoparius—Bouteloua curtipendula* association, *Bouteloua hirsuta—B. curtipendula* association, and *Stipa spartea—Andropogon scoparius* association, July-October. Not numerous.

*Mestobregma kiowa kiowa* Thom.

At *Bouteloua hirsuta—B. curtipendula* association, Ocheyedan Mound, July 23, 1928, and *Andropogon scoparius—Bouteloua curtipendula* association, Oak Grove State Park, July 25, 1928. Not numerous.

*Arphia pseudonietana* Thom.

At *Stipa spartea—Andropogon scoparius* association, 6 mi. northwest of Ledyard, one specimen.

*Chortophaga viridifasciata* DeG.

At *Andropogon furcatus* associes, and *Stipa spartea—Andropogon scoparius* association. The author (1928) reported earliest adult, April 21; latest adults, May 28, 1926. Nymphs found as early as March 10, and as late as Oct. 20. Not numerous.

*Encoptolophus sordidus* Burm.

At *Andropogon furcatus* consocies, and *Stipa spartea—Andropogon scoparius* association. The author (1928) reports earliest adult, Aug. 7; latest adult, Oct. 1, 1926. Not numerous in any community, but probably occurs in largest number at *Bouteloua hirsuta—B. curtipendula* association as reported by the author (1928).

*Hippiscus apiculatus* Harr.

Not met with since report by author (1928) when taken as adult May 15-June 4, 1926. Probably characteristic of *Bouteloua hirsuta—B. curtipendula* association, and *Andropogon scoparius—Bouteloua curtipendula* association, but not numerous.

*Hippiscus haldemanii* Scudd.

At *Stipa spartea—Andropogon scoparius* association, northeast of Iowa State College grounds, July 11, 1928. Rare.

*Hesperotettix pratensis* Scudd.

At *Andropogon scoparius—Bouteloua curtipendula* association, Gitchie-Manito State Park to Sergeant Bluff, July 24-26, 1928. Not numerous.

*Hesperotettix speciosa* Scudd.

At *Andropogon scoparius—Bouteloua curtipendula* association, 15 mi. north of Sioux City, July 26, 1928, one specimen.

*Schistocerca alutacea* ? Harr.

At *Andropogon scoparius—Bouteloua curtipendula* association, 1 mi. west of Hamburg State Park, July 30, 1928, and Sergeant Bluff, July 26, 1928. All specimens are nymphs.

*Melanoplus dawsoni* Scudd.

At *Andropogon scoparius—Bouteloua curtipendula* association, *Bouteloua hirsuta—B. curtipendula* association, and *Stipa spartea—Andropogon scoparius* association. The author (1928) records this species at *Stipa—Bouteloua* community with July 15 as earliest date of collection of adult, and Oct. 9, the latest date.

*Melanoplus scudderi* ? Uhl.

One specimen at *Polygonum* socies, 10 mi. southwest of Kelso, July 30, 1928.

*Melanoplus mexicanis atlanis* Riley

At *Andropogon scoparius—Bouteloua curtipendula* association, Gitchie-Manito State Park to Council Bluffs, July 24-Aug. 1, 1928, and at *Andropogon furcatus* consocies, 2.5 mi. south of Ames, June 23 and Aug. 26, 1926. More numerous in western communities.

*Melanoplus femur-rubrum* DeG.

At all *Andropogon* communities. Earliest adult, July 26, 1928; latest adult, Aug. 24, 1928. Most numerous at *Andropogon furcatus* consocies.

*Melanoplus packardii* Scudd.

At *Andropogon scoparius—Bouteloua curtipendula* association, 15 mi. north of Sioux City to 1 mi. west of Hamburg State Park, July 26 to July 31, 1928. Scarce.

*Melanoplus confusus* Scudd.

At *Andropogon furcatus* consocies, 3.5 mi. north of Ledyard, July 7, 1928, 2 specimens; at *Andropogon scoparius—Bouteloua curtipendula* association, Oak Grove State Park, July 25, 1928, one specimen. The author (1928) took this species at *Stipa—Bouteloua* community, May 3-Aug. 14, 1926. Only a few specimens have been secured.

*Melanoplus keeleri luridus* Dodge

At all *Andropogon* communities. Earliest adult, June 23, 1928; latest adult, Oct. 20, 1928. Most numerous at *Stipa spartea—Andropogon scoparius* association and *Andropogon scoparius—Bouteloua curtipendula* association.

*Melanoplus differentialis* Thom.

At *Andropogon furcatus—Spartina Michauxiana* associes where tall herbs such as *Helianthus grosseserratus* occur. Earliest adult, Aug. 20, 1927; latest adult, Oct. 20, 1928. Not numerous.

*Melanoplus bivittatus* Say

At all *Andropogon* communities. Earliest adult, July 24, 1928; latest adult, Aug. 5, 1927. Not numerous.

*Phoetaliotes nebrascensis* Thom.

The author (1928) records this species from a *Stipa—Bouteloua* community, and it is probably most numerous at the *Bouteloua hirsuta—B. curtipendula* association.

*Arethaea gracilipes constricta* Brunn.

At *Andropogon scoparius—Bouteloua curtipendula* association, 1 mi. west of Hamburg State Park, July 30, 1928, quite common.

*Scudderia texensis* S. P.

At *Andropogon furcatus—Spartina Michauxiana* associes. Earliest adult, July 20, 1925; latest adult, Aug. 13, 1927. Probably most frequently met at *Spartina* consocies.

*Scudderia pistillata* Brunn.

At *Andropogon furcatus* consocies, 6 mi. northwest of Le Mars, July 26, 1928, two specimens.

*Scudderia furcata* Brunn.

At *Carex* socies, 1 mi. south of Amana, Aug. 25, 1928, two specimens, and at *Andropogon furcatus—Sorghastrum nutans* associes, 6 mi. south of Washington, Sept. 7, 1928.

*Amblycorypha rotundifolia brachyptera* Ball

At *Andropogon furcatus—Spartina Michauxiana* associes. Earliest adult, July 5, 1926; latest adult, Aug. 31, 1927. Not numerous. Most taken at *Andropogon* consocies.

*Neoconocephalus ensiger* Harr.

At *Andropogon* communities. Earliest adult, July 17, 1926; latest adult, Aug. 25, 1928. Most of the specimens were taken at *Andropogon furcatus* consocies.

*Orchelimum vulgare* Harr.

At *Andropogon furcatus—Spartina Michauxiana* and *Andropogon furcatus—Sorghastrum nutans* associes. Earliest adult, July 30, 1928; latest adult, Aug. 24, 1928. Most of the specimens were taken at *Spartina* consocies.

*Orchelimum gladiator* Brunn.

At *Spartina* consocies, 2.5 mi. north of Ames, Aug. 5, 1927, three specimens.

*Orchelimum nigripes* Scudd.

At *Andropogon furcatus—Spartina Michauxiana* and *Andropogon furcatus—Sorghastrum nutans* associes. Earliest adult, Aug. 12, 1927; latest adult, Aug. 24, 1928. Most of the specimens were taken at *Spartina* consocies. Not numerous.

*Orchelimum concinnum* Scudd.

At *Spartina* consocies. Earliest adult, July 30, 1928; latest adult, Aug. 7, 1928. Not numerous.

*Conocephalus fasciatus* DeG.

At *Andropogon furcatus—Spartina Michauxiana* associes. Earliest adult, July 24, 1928; latest adult, Sept. 7, 1927. More common where grasses are taller.

*Conocephalus brevipennis* Scudd.

At *Andropogon furcatus—Spartina Michauxiana* and *Andropogon furcatus—Sorghastrum nutans* associes. Scarce.

*Conocephalus nemoralis* Scudd.

At *Spartina* consocies, Lake Amana, Aug. 31, 1927, one specimen.

*Conocephalus strictus* Scudd.

At all *Andropogon* communities except *Andropogon scoparius—Bouteloua curtipendula* association. Earliest adult, July 31, 1928; latest adult, Sept. 19, 1928. Common. Collections most numerous from *Andropogon furcatus* consocies.

*Conocephalus attenuatus* Scudd.

At *Spartina* consocies, Lake Amana, Aug. 12, 1927, five specimens.

*Conocephalus nigropleurus* Brunn.

At *Spartina* consocies, 2.5 mi. north of Ames, July 16, 1928, one specimen.

*Conocephalus saltans* Scudd.

At all *Andropogon* communities. Earliest adult, July 23, 1928; latest adult, Oct. 20, 1928. Collections most numerous at *Stipa spartea—Andropogon scoparius* associations. Common.

*Udeopsylla nigra* Scudd.

At *Stipa spartea—Andropogon scoparius* association, under stones, 2 mi. north of Ames, April 25, 1927, one specimen, and 5 mi. south of Stanhope, April 25, 1928, one specimen. Both specimens are young nymphs.

*Pediodectes* sp.

At *Andropogon scoparius—Bouteloua curtipendula* association, 15 mi. north of Sioux City, July 26, 1928, one specimen.

*Nemobius fasciatus* DeG.

At all *Andropogon* communities. Earliest adult, Aug. 11, 1925; latest adult, Oct. 20, 1928. Common wherever taller plants, dead vegetation and stones provide more shelter and moisture than open situations.

*Gryllus assimilis* Fab.

At all *Andropogon* communities. Earliest adult, May 2, 1926; latest adult, Oct. 20, 1928. Quite common wherever taller plants, decaying vgeetation, stones, burrows of crayfish, depressions and cracks in the soil provide hiding places and cover.

*Oecanthus nigricornis nigricornis* Walk.

At *Andropogon* communities close to wooded tracts; one specimen, 1 mi. south of Amana, Aug. 25, 1928, and two specimens, 6 mi. south of Washington, Sept. 7, 1927, and Aug. 24, 1928.

*Oecanthus nigricornis argentinus* Sauss.

At *Andropogon scoparius—Bouteloua curtipendula* association, 4 mi. northeast of Beloit to Council Bluffs, July 25 to July 31, 1928. Not numerous.

*Oecanthus nigricornis quadripunctatus* Beut.

At all *Andropogon* communities. Earliest adult, Aug. 5, 1927; latest adult, Oct. 20, 1928. Collections are most numerous from *Stipa spartea—Andropogon scoparius* association.

*Anaxipha exigua* Say

At *Spartina* consocies, 10 mi. southwest of Kelso, July 30, 1928. Not numerous. Adults and nymphs collected.

## ORDER NEUROPTERA

The determinations of species were made by Mr. Nathan Banks. The arrangement follows Bank (1907).

*Hemerobius stigmaterus* Fh.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Sept. 17, 1926, one specimen.

*Micromus subanticus* Wlk.

At *Andropogon* consocies, 2.5 mi. south of Ames, May 25, 1926.

*Micromus variolosus* Hag.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Sept. 24, 1926.

*Chrysopa oculata* Say

At all plant communities. Earliest adult, June 26, 1928; latest adult, Aug. 19, 1927. A common lacewing.

*Chrysopa plorabunda* Fh.

At all communities except *Andropogon scoparius—Bouteloua curtipendula* association. Earliest adult, July 6, 1928; latest adult, Aug. 24, 1928.

## ORDER EPHEMERIDA

The determinations of species were made by Mr. G. S. Walley. The arrangement of species follows Banks (1907).

*Hexagenia venusta* Eaton

At *Carex* socies, Lake Amana, June 23, 1928.

*Hexagenia* sp.

At *Andropogon scoparius—Bouteloua curtipendula* association, 4 mi. northeast of Beloit, July 27, 1928. The Big Sioux river is about two miles west of this location. Six specimens.

*Blasturus nebulosus* Wlk.

At *Spartina* consocies, 2.5 mi. north of Ames, May 7, 1928, one specimen. Skunk River is about one-fourth mile east of this location. At *Stipa spartea—Andropogon scoparius* association, 5 mi. south of Stanhope, April 25, 1928. Several permanent ponds and streams occur within a mile of this location.

*Callibaetis* sp.

At *Bouteloua hirsuta—B. curtipendula* and *Stipa spartea—Andropogon scoparius* association, 1.5 mi. northeast of Ocheyedan, July 27, 1928, five specimens. Rush Lake lies about one-eighth mile north of this location.

*Isonychia* sp. probably *manca* Eaton

At *Andropogon scoparius—Bouteloua curtipendula* association, 4 mi. northeast of Beloit, July 27, 1928, three specimens.

## ORDER ODONATA

The determinations were made by Mr. B. E. Montgomery. The arrangement follows Needham and Heywood (1929).

*Nehalennia irene* Hag.

At *Andropogon* associes, 2.5 mi. south of Ames, July 20, 1925, one female specimen.

*Enallagma hageni* Walsh

At *Spartina* consocies, 2.5 mi. south of Ames, July 3, 1926, one male specimen.

*Ischnura posita* Hag.

At *Spartina* consocies, 2.5 mi. south of Ames, two female specimens.

*Ischnura verticalis* Say

At *Spartina* consocies, 2.5 mi. south of Ames, May 20, 1927, one female specimen.

## ORDER PLECOPTERA

The species was determined by Dr. P. W. Claassen.

*Perlesta placida* Hag.

At *Carex* socies, 1 mi. south of Amana, June 23, 1928, three specimens. The Iowa River is at the southern border of this tract.

## ORDER THYSANOPTERA

The species was determined by Dr. J. Douglas Hood.

*Frankliniella tritici* Fitch

Taken from the flower of *Ranunculus septentrionalis,* 2.5 mi. south of Ames, May 17, 1926.

## ORDER HEMIPTERA

The species were determined by Drs. H. H. Knight, C. J. Drake, H. M. Harris and Mr. H. G. Barber. The arrangement follows Van Duzee (1917), mainly.

*Homaemus aeneifrons* Say

At *Stipa spartea—Andropogon scoparius* association, northeast of Iowa State College campus, July 11, 1928. Swept from *Sorghastrum nutans,* 1.5 mi. ease of Verdi, Sept. 5, 1928. One specimen at each location.

*Homaemus bijugis* Uhl.

At all higher *Andropogon* communities. Earliest adult, July 7, 1928; latest adult, Oct. 20, 1928. Most frequent at *Stipa spartea—Andropogon scoparius* association, where it is common.

*Eurygaster alternatus* Say

At *Andropogon furcatus* consocies, 2 mi. south of Ledyard, May 8, 1926, one specimen. At *Andropogon scoparius* communities, Sergeant Bluffs, July 25, 1928, one specimen, and 7.75 mi. northeast of Thompson, Aug. 6, 1928, one specimen.

*Galgupha atra* A. & S.

At *Andropogon furcatus—Spartina Michauxiana* associes. Earliest adult, May 20, 1927; latest adult, Aug. 13, 1927. Swept from *Elymus virginicus,* 1 mi. south of Amana, Aug. 12, 1927. Most numerous at *Spartina* consocies.

*Galgupha nitiduloides* Wolff.

At flowers of *Pedicularis canadensis,* 2.5 mi. south of Ames, May 12, 1926, two specimens. At *Andropogon furcatus* consocies, same location, May 17, 1926, one specimen.

*Corimelaena agrella* McA.

At *Andropogon scoparius—Bouteloua curtipendula* association, 1 mi. west of Hamburg State Park to Sergeant Bluff, July 26-31, 1928, six specimens.

*Corimelaena lateralis* Fabr.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 22, 1925, one specimen. Feeding on fruit of *Zizia aurea,* 1 mi. south of Amana, Aug. 12, 1927. At *Andropogon furcatus—Sorghastrum nutans* associes, July 20, 1928, one specimen.

*Corimelaena pulicaria* Germ.

At *Andropogon furcatus—Spartina Michauxiana* associes, from flowering *Polygonum amphibium, Veronica virginica, Cicuta maculata,* most frequently. Earliest adult, May 18, 1928; latest adult, Aug. 9, 1928. Common. At *Andropogon scoparius—Bouteloua curtipendula* association, Council Bluffs, July 31, 1928.

*Pangaeus bilineatus* Say

At *Spartina* consocies, on ground, 10 mi. southwest of Kelso, July 30, 1928, one specimen.

*Amnestus spinifrons* Say

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, June 19, 1926, one specimen.

*Amnestus pallidus* Zimm.

At *Spartina* consocies, 2.5 mi. south of Ames, May 20, 30, June 5, 1927, three specimens.

*Sehirus cinctus* P. B.

Swept from *Spartina* consocies, 2.5 mi. south of Ames, July 6, 1926, and *Carex* socies, same location, June 26, 1926. Taken at flower of *Liatris pycnostachya,* Aug. 5, 1926. One specimen in each case.

*Podops cinctipes* Say

At *Spartina* consocies, 2.5 mi. south of Ames, May 30, 1927, one specimen.

*Sciocoris microphthalmus* Flor.

At *Andropogon scoparius—Bouteloua curtipendula* association, 15 mi. north of Sioux City, July 26, 1928.

*Peribalus limbolarius* Stal

At all plant communities. Earliest adult, July 11, 1928; latest adult, 5 mi. south of Stanhope, Oct. 20, 1928. On flowers of *Veronica virginica* Aug. 2, 5, 9, 1926, 2.5 mi. south of Ames. On flowers of *Solidago rigida,* 5 mi. south of Stanhope, Sept. 19, 1928. A common stinkbug, most numerous at *Stipa spartea—Andropogon scoparius* association, and *Andropogon furcatus* consocies.

*Trichopepla semivittata* Say

At flower of *Eryngium yuccifolium,* Aug. 14, 1925, 2.5 mi. south of

Ames, and at *Andropogon furcatus* consocies, same location, Aug. 26, 1926. Two specimens.

*Trichopepla atricornis* Stal

At *Stipa spartea—Andropogon scoparius* association and *Andropogon furcatus—Spartina Michauxiana* associes. Earliest adult, July 27, 1926; latest adult, Aug. 16, 1928. On fruit of *Zizia aurea,* 2.5 mi. south of Ames, July 4, 1928, and on flower of *Erigeron ramosus,* 1 mi. south of Amana, June 23, 1928. Most frequent at *Stipa spartea—Andropogon scoparius* association and *Andropogon furcatus* consocies where the species is common.

*Chlorochroa uhleri* Stal

At *Andropogon scoparius—Bouteloua curtipendula* association, Council Bluffs, July 26, 1928, one specimen.

*Mormidea lugens* Fabr.

At *Andropogon furcatus—Spartina Michauxiana* association, 2.5 mi. south of Ames, July 22, Aug. 9, 1926. Not numerous. At *Spartina* consocies, 1 mi. south of Amana, Aug. 12, 1927, one specimen.

*Euschistus euschistoides* Voll.

At *Spartina* consocies, 1 mi. south of Amana, Aug. 12, 1927, and at *Elymus virginicus,* 1 mi. south of Amana, Aug. 13, 1927. At *Carex* socies, 10 mi. southwest of Kelso, July 30, 1928. One specimen at each community.

*Euschistus variolarius* P. B.

At all communities. Earliest adult, May 15, 1926; latest adult, Oct. 20, 1928. Most numerous at *Stipa spartea—Andropogon scoparius* association, and *Andropogon furcatus* consocies. Feeding on flower of *Lepachys pinnata,* 1 mi. south of Amana, July 20, 1928. On *Astragalus caryocarpus,* 5 mi. south of Stanhope, June 15, 1928. The most common Pentatomid of the prairie.

*Coenus delius* Say

At all communities. Earliest adult, April 25, 1928; latest adult, Aug. 24, 1928. Most frequent at *Andropogon scoparius—Bouteloua curtipendula* and *Stipa spartea—Andropogon scoparius* associations. Not numerous at any community.

*Neottiglossa undata* Say

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Aug. 14, 1926; *Spartina* consocies 2.5 mi. south of Ames, July 11, 1928; *Spartina* consocies, 1 mi. south of Amana, Aug. 12, 1927; *Stipa spartea—Andropogon scoparius* association, 3.5 mi. north of Ledyard, Aug. 7, 1928. Scarce.

*Neottiglossa sulcifrons* Stal

At *Andropogon scoparius—Bouteloua curtipendula* association, Gitchie-Manito State Park to Sergeant Bluff, July 24-26, 1928. Not numerous.

*Cosmopepla bimaculata* Thom.

At *Spartina* consocies, 2.5 mi. north of Ames, July 16, 1928, 1 mi. south of Amana, Aug. 12, 1927, and 10 mi. southwest of Kelso, July 30, 1928.

At *Andropogon scoparius,* 7.75 mi. northwest of Thompson, Aug. 6, 1928. Not numerous.

*Prionosoma podopioides* Uhl.

At *Andropogon scoparius—Bouteloua curtipendula* association, Council Bluffs, July 31, 1928, one specimen.

*Thyanta custator* Fabr.

At *Andropogon scoparius—Bouteloua curtipendula* association, Sergeant Bluff, July 26, 1928, one specimen.

*Banasa dimidiata* Say

At *Andropogon scoparius—Bouteloua curtipendula* association, 1 mi. west of Hamburg State Park, July 30, 1928, one specimen.

*Stiretrus fimbriatus* Say

At *Spartina* consocies, 1 mi. south of Amana, Aug. 13, 1927, one specimen.

*Apateticus* sp.

At *Carex* socies, 7.75 mi. northwest of Thompson, June 30, 1928, two nymphs. One nymph was feeding on a small ground beetle when taken.

*Podisus maculiventris* Say

At *Spartina* consocies, and *Polygonum amphibium* socies, nearly all of the specimens, where they are common. Earliest adult, June 26, 1926; latest adult, Aug. 13, 1927.

*Merocoris distinctus* Dall.

At *Stipa spartea—Bouteloua curtipendula* association, 2 mi. north of Ames, July 11, 1928, four specimens. At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 20, 1925, one specimen.

*Euthochtha galeator* Fabr.

Swept from *Solidago* sp., 1 mi. south of Amana, June 23, 1928, one specimen.

*Protenor belfragei* Hagl.

Taken on *Spartina* consocies, Lake Amana, Aug. 12, 31, 1927, seven specimens. At *Spartina* consocies, 6 mi. northwest of Cedar Falls, July 17, 1926, three specimens. At *Carex* socies, 7.75 mi. northwest of Thompson, Sept. 15, 1928, one specimen, and at *Stipa spartea—Andropogon scoparius* association, Aug. 6, 1928, two specimens.

*Alydus eurinus Say*

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Aug. 7, 11, 1925. At *Spartina* consocies, 10 mi. southwest of Kelso, July 30, 1928, one specimen. On *Amorpha canescens,* 3 mi. south of Muscatine, Sept. 1, 1928. At *Cassia Chamaecrista,* in bloom, 1 mi. south of Amana, Aug. 25, 1928, several specimens. At *Andropogon furcatus* consocies, 6 mi. northwest of Cedar Falls, July 17, 1928, and at *Andropogon furcatus—Sorghastrum nutans* associes, 6 mi. south of Washington, Sept. 7, 1927. Not numerous.

*Alydus conspersus* Montd.

At *Andropogon furcatus* consocies, *Andropogon furcatus—Sorghastrum nutans* association, and *Andropogon scoparius—Bouteloua curtipendula* association. Earliest adult, July 17, 1926; latest adult, Sept. 1, 1928. Breeding on *Amorpha canescens* at several stations. Common.

*Alydus pilosulus* H. S.

At *Andropogon furcatus* consocies, *Andropogon furcatus—Sorghastrum nutans* associes, *Andropogon scoparius—Bouteloua curtipendula* association, and *Stipa spartea—Andropogon scoparius* association. Earliest adult, July 17, 1926; latest adult, Oct. 20, 1928. On *Amorpha canescens,* 3 mi. south of Muscatine, Sept. 1, 1928. Not numerous.

*Harmostes reflexulus* Say

At *Andropogon furcatus* associes, *Andropogon scoparius—Bouteloua curtipendula* association, and *Stipa spartea—Andropogon scoparius* association. Earliest adult, July 16, 1925; latest adult, Oct. 20, 1928. Not numerous.

*Ceraleptus americanus* Stal

At *Andropogon scoparius—Bouteloua curtipendula* association, Gitchie-Manito State Park, July 24, 1928, one specimen.

*Aufeius impressicollis* Stal

At *Stipa spartea—Andropogon scoparius* association, 7.75 mi. northwest of Thompson, June 30, 1928, one specimen.

*Corizus viridicatus* Uhl.

At *Andropogon scoparius—Bouteloua curtipendula* association, July 25-Aug. 1, 1928, scarce. At *Bouteloua* community, Ocheyedan Mound, July 23, 1928, one specimen. At flower of *Dyssodia papposa,* Oak Grove State Park, July 25, 1928, one specimen.

*Corizus bohemanii* Sign.

Nearly all specimens are from *Spartina* consocies, and *Polygonum amphibium* socies. Earliest adult, July 19, 1926; latest adult, Sept. 1, 1928. Common.

*Jalysus spinosus* Say

At *Andropogon furcatus—Spartina Michauxiana* associes, 2.5 mi. south of Ames, July 26, Aug. 2, 1926, two specimens. On flowers of *Gaura parviflora,* 1 mi. south of Amana, Aug. 26, 1928. At *Andropogon furcatus* consocies, 6 mi. northwest of Cedar Falls, July 17, 1928. Not numerous.

*Lygaeus kalmii* Stal

At *Andropogon furcatus—Spartina Michauxiana* associes, 2.5 mi. south of Ames, Aug. 17, 1925, June 19, 1926. At *Andropogon scoparius—Bouteloua curtipendula* association, Council Bluffs, July 31, 1928, Oak Grove State Park, July 25, 1928. Five specimens, in total, collected.

*Lygaeus bicrucis* Say

At *Andropogon furcatus—Spartina Michauxiana* associes, nearly all specimens. Earliest adult, May 12, 1927; latest adult, Aug. 25, 1928. At flowers of *Cicuta maculata,* most frequently, where they are numerous at times.

*Ortholomus scolopax* Say

At *Andropogon furcatus* associes. At *Andropogon scoparius—Bouteloua curtipendula* association, and *Stipa spartea—Andropogon scoparius* association, more frequent. Earliest adult, July 25, 1928; latest adult, Sept. 19, 1928. Not numerous.

*Nysius californicus* Stal

At *Andropogon furcatus* consocies, nearly all specimens, less at *Spartina* consocies. Earliest adult, July 17, 1926; latest adult, Aug. 26, 1926. At flower of *Silphium laciniatum,* July 15, 1926, and flowers of *Cicuta maculata,* Aug. 4, 1928. Not numerous.

*Nysius ericae* Schill.

At all communities higher than *Spartina* consocies. Earliest adult, April 17, 1927; latest adult, Aug. 5, 1928. Taken in largest numbers at *Bouteloua hirsuta—B. curtipendula* association, Ocheyedan Mound, July 23, 1928.

*Cymus angustatus* Stal

At *Spartina* consocies, 2.5 mi. south of Ames, May 12, 30, 1927, three specimens. At *Carex* socies, 1 mi. south of Amana, June 23, 1928, one specimen.

*Cymus luridus* Stal

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, May 12, 1927, one specimen, and at *Spartina* consocies, 4 mi. northwest of Thompson, May 18, 1928, one specimen.

*Ischnodemus falicus* Say

At *Spartina* consocies, numerous. Earliest adult, April 16, 1927; latest adult, Aug. 25, 1928. Nymphs found only on *Spartina Michauxiana;* most frequently in July and August.

*Blissus leucopterus* Say

At *Polygonum amphibium* socies, 2 mi. west of Pacific Junction, July 31, 1928, one specimen.

*Geocoris uliginosus limbatus* Stal

At all communities higher than *Spartina* consocies. Earliest adult, June 16, 1926; latest adult, Aug. 14, 1926. Most frequently taken on ground; not numerous where sod is close, but easily obtained where grasses are more bunchy. A nymph obtained at *Bouteloua hirsuta—B. curtipendula* association, 2 mi. north of Ames, Aug. 18, 1926, moulted into an adult at the end of five days after feeding on four small leafhoppers.

*Phlegyas abbreviatus* Uhl.

At *Andropogon furcatus—Sorghastrum nutans* associes, 1 mi. south of Amana, July 20, 1928, one specimen, and 6 mi. south of Washington, 2 specimens, Sept. 7, 1927. At *Spartina* consocies, 1 mi. south of Amana, Aug. 12, 1927, one specimen.

*Oedancala dorsalis* Say

At *Andropogon furcatus—Spartina Michauxiana* associes, 1 mi. south of Amana, Aug. 12, 13, 1927, June 23, Aug. 25, 1928, eight specimens of which five are from *Spartina* consocies. At *Spartina* consocies, 10 mi. southwest of Kelso, July 30, 1928, one specimen.

*Sphaerobius insignis* Uhl.

At all communities higher than *Spartina* consocies except *Bouteloua hirsuta—B. curtipendula* association. Earliest adult, June 5, 1928; latest adult, Aug. 7, 1928. Most frequent at *Stipa spartea—Andropogon scoparius* association, Ocheyedan Mound, July 23, 1928, where they were one of the most common insects.

*Ligyrocoris diffusus* Uhl.

At all communities. Earliest adult, June 23, 1928; latest adult, Oct. 20, 1928. Most numerous at *Andropogon furcatus* associes, where herbaceous plant flowers attracted many of this species.

*Zeridoneus costalis* V. D.

At *Stipa spartea—Andropogon scoparius* association, 5 mi. northwest of Buffalo Center, Aug. 6, 1928, and 6 mi. northwest of Ledyard, Aug. 7, 1928, four specimens. At *Andropogon scoparius—Bouteloua curtipendula* association, Oak Grove State Park, July 25, 1928, one specimen.

*Pseudocnemodus canadensis* Prov.

At all communities higher than *Spartina* consocies except *Andropogon scoparius—Bouteloua curtipendula* association. Earliest adult, June 28, 1928; latest adult, Oct. 20, 1928. Not numerous at any community.

*Emblethis vicarius* Horv.

At *Stipa spartea—Andropogon scoparius* association 2 mi. north of Ames, June 24, 1926, one specimen. At *Andropogon scoparius—Bouteloua curtipendula* association, Sergeant Bluff, July 26, 1928, two specimens.

*Piesma cinerea* Say

At *Andropogon furcatus—Spartina Michauxiana* associes, 2.5 mi. south of Ames, May 30, June 5, 1927, 8 mi. southeast of Britt. One specimen on each date.

*Acalypta lillianis* Bueno

Among moss of *Spartina* consocies, 2.5 mi. south of Ames, April 22, 1928, one nymph. In company with Dr. Drake, the author found seven nymphs in the same situation, Aug. 14, 1927. These nymphs lived until November, 1927, on moss indoors. Several nymphs were found on moss in *Andropogon furcatus* consocies, Oct. 9, 1928, 2.5 mi. south of Ames. Drake

(1928) has summarized the observations of several workers which connect the species with moss.

*Melanorhopala clavata* Stal

At *Andropogon furcatus* consocies and *Andropogon furcatus—Sorghastrum nutans* ascocies. Earliest adult, June 5, 1926; latest adult, July 28, 1925. At 1 mi. south of Amana two adult specimens were observed with beaks inserted into upper portion of a stem of *Solidago* sp., Aug. 13, 1928. One of the specimens appeared to feed for 15 minutes. These individuals were observed feeding on the same plant in a cage during several weeks in August. No evidence of the species breeding on this species of plant was obtained.

*Atheas mimeticus* Heid.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Aug. 17, 1926, one specimen. Numerous at a family of *Petalostemum candidum,* 7.75 mi. northwest of Thompson, Aug. 6, 1928, where nymphs and adults were found.

*Phymata erosa fasciata* Gray

At all communities, on flowers of various herbaceous plants. Earliest adult, July 10, 1925; latest adult, Oct. 20, 1928. Most numerous at *Andropogon* communities, where *Compositae* are frequent.

*Fitchia aptera* Stal

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 29, 1925, April 16, 1927, Mar. 25, 1928, one specimen at each date. Swept from *Anemone canadense,* 1 mi. south of Amana, June 23, 1928, one specimen.

*Sinea diadema* Fab.

At all *Andropogon* communities. Earliest adult, July 23, 1928; latest adult, Oct. 20, 1926. Common at several communities. Most of the specimens were at *Stipa spartea—Andropogon scoparius* association.

*Pagasa fusca* Stein

Swept from *Solidago canadensis,* 1 mi. south of Amana, Aug. 25, 1928, one specimen.

*Nabis subcoleoptratus* Kirby

At *Andropogon furcatus—Spartina Michauxiana* associes, and *Stipa spartea—Andropogon scoparius* association. Earliest collection, June 15, 1928; latest, Aug. 6, 1928. Numerous at *Stipa spartea—Andropogon scoparius* association, 5 mi. south of Stanhope, June 15, 1928, but not common at any other station. One of the specimens has long wings.

*Nabis propinquus* Reut.

At *Stipa spartea—Andropogon scoparius* association, 8 mi. southeast of Britt, July 6, 1928, two specimens.

*Nabis capsiformis* Germ.

At *Spartina* consocies, 2 mi. west of Kelso, July 30, 1928, one specimen.

*Nabis ferus* Linn.

At all communities. Earliest adult, March 25, 1928; latest adult, Oct. 20, 1928. More numerous at communities higher than *Spartina* consocies. At Ocheyedan Mound, July 23, 1928, adult specimen taken while feeding on a Hemipterous nymph.

*Nabis ferus* var. *pallidipennis* Harris

At *Andropogon furcatus—Spartina Michauxiana* associes. Earliest adult, May 2, 1928; latest adult, Aug. 9, 1928. Most of the specimens are from *Spartina* consocies, where it is probably one of the more common insects.

*Nabis alternatus* Parsh.

At *Andropogon furcatus—Spartina Michauxiana* associes, 8 mi. southeast of Britt, Aug. 9, 1928, 2.5 mi. south of Ames, April 22, 1928. One specimen on each date. At *Andropogon scoparius,* 7.75 mi. northwest of Thompson, Aug. 6, 1928, one specimen.

*Xylocoris sordidus* Reuter

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Aug. 25, 1925, one specimen.

*Triphleps insidiosus* Say

At nearly all communities. Common at flowers, especially of *Compositae.* Earliest adult, May 19, 1926; latest adult, Sept. 15, 1928.

*Collaria oculata* Reut.

At *Spartina* consocies, 1 mi. south of Amana, Aug. 12, 1927, one specimen.

*Miris dolabratus* Linn.

At *Andropogon furcatus—Sorghastrum nutans* associes, where timothy (*Phleum pratense*) had invaded, 1 mi. south of Amana, June 23, 1928, six specimens.

*Stenodema vicinum* Prov.

At *Spartina* consocies, 2.5 mi. south of Ames, July 15, 1926, and 7.75 mi. northwest of Thompson, Aug. 6, 1928. At *Andropogon furcatus* consocies, 3.5 mi. north of Ledyard, Aug. 7, 1928. One specimen on each date.

· *Trigonotylus ruficornis* Geoff.

At *Stipa spartea—Andropogon scoparius* association, 3.5 mi. north of Ledyard, Aug. 7, 1928, one specimen.

*Trigonotylus tarsalis* Reut.

At *Spartina* consocies. Earliest adult, May 20, 1927; latest adult, Sept. 15, 1928. Numerous. Nymphs on *Spartina Michauxiana* numerous during August.

*Teratocoris discolor* Uhl.

At *Spartina* consocies, 8 mi. southeast of Britt, Aug. 9, 1928, two specimens, and .5 mi. south of Missouri Valley, Aug. 1, 1928, six specimens.

*Teratocoris paludum* J. Sahlb.

At *Carex* socies, Lake Amana, June 23, 1928, one specimen.

*Platytylellus nigricollis* Reut.

At *Andropogon furcatus* consocies, 6 mi. northwest of Cedar Falls, July 17, 1926, two specimens.

*Mimoceps insignis* Uhl.

At *Spartina* consocies and *Carex* socies, 1 mi. south of Amana, June 23, Aug. 12, 1928, three specimens. At *Andropogon furcatus* consocies, 3.5 mi. north of Ledyard, Aug. 7, 1928.

*Neurocolpus nubilus* Say

At *Andropogon scoparius—Bouteloua curtipendula* association, 15 mi. north of Sioux City, July 26, 1928, three specimens.

*Adelphocoris rapidus* Say

At all communities. Earliest adult, June 15, 1928; latest adult, Oct. 20, 1928. Most numerous at flowers of *Compositae* of *Andropogon furcatus* consocies, but common at all species of blooming herbaceous plants.

*Polymerus basalis* Reut.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 27, 1925, one specimen. At *Andropogon scoparius—Bouteloua curtipendula* association, 1 mi. north of Reels City, Aug. 1, 1928, six specimens.

*Polymerus basalis fuscatus* Knight

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Sept. 24, 1926, one specimen.

*Polymerus chrysopsis* Knight

At *Andropogon scoparius—Bouteloua curtipendula* association, Gitchie-Manito State Park, July 24, 1928, two specimens.

*Polymerus venaticus* Uhl.

At *Carex socies,* Lake Amana, June 23, 1928, and swept from *Solidago canadensis,* 1 mi. south of Amana, June 23, 1928. One specimen at each location.

*Capsus simulans* Stal

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, May 21, 1926, one specimen.

*Lygus pratensis* Linn.

At all communities. Earliest adult, Mar. 21, 1926; latest adult, Sept. 19, 1928. Most numerous at higher associations such as *Bouteloua hirsuta —B. curtipendula, Andropogon scoparius—Bouteloua curtipendula,* and *Stipa spartea—Andropogon scoparius.* One of the common insects of these associations at flowers of herbaceous plants.

*Lygus pratensis oblineatus* Say

At all communities. Most numerous at *Andropogon furcatus—Spartina Michauxiana* associes. Earliest adult, Mar. 23, 1926; latest adult, Oct. 20, 1928. Adults and nymphs numerous at flowers of *Erigeron ramosus,* 1 mi. south of Amana, June 23, 1928. Adults numerous at flowers on *Anemone canadense,* same location and date. Numerous at flowers of *Cicuta maculata,* 5 mi. northwest of Buffalo Center, July 7, 1928. One of the most numerous insects of the lower communities.

*Lygus pratensis strigulatus* Walk.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 31, 1926, one specimen. At *Andropogon furcatus—Sorghastrum nutans* associes, 1 mi. south of Amana, June 23, 1928, one specimen.

*Lygus plagiatus* Uhl.

At *Andropogon furcatus—Spartina Michauxiana* associes, chiefly. Earliest adult, June 23, 1928; latest adult, Sept. 19, 1928. Twelve of the fifteen specimens were taken at *Spartina* consocies. Not numerous at any station.

*Lygus campestris* Linn.

At *Andropogon furcatus—Spartina Michauxiana* associes. Earliest adult, Mar. 21, 1928; latest adult, Aug. 9, 1928. Taken most frequently at flowers of *Cicuta maculata.* A common insect in *Spartina* consocies where *Cicuta maculata* is abundant.

*Deraeocoris histrio* Reut.

At *Polygonum amphibium* socies. Earliest adult, May 12, 1927; latest adult, Sept. 16, 1928. Sometimes numerous. A nymph, taken Aug. 4, 1928, fed upon a small Lepidopterous larva taken on *Polygonum amphibium* and a leafhopper (*Dikraneura fieberi*). It fed upon leaf of *Polygonum amphibium,* Aug. 7, 1928. Molted into adult Aug. 7, 1928.

*Coquillettia mimetica* Osborn

At *Andropogon scoparius—Bouteloua curtipendula* association, 4 mi. northeast of Beloit, July 25, 1928, common. A few nymphs were taken from *Bouteloua curtipendula,* and the adults seemed more numerous at the same grass.

*Dicyphus vestitus* Uhl.

At *Spartina* consocies, 2 mi. west of Kelso, July 30, 1928, one specimen.

*Halticus intermedius* Uhl.

At *Andropogon scoparius—Bouteloua curtipendula* association 15 mi. north of Sioux City, one specimen, July 26, 1928.

*Strongylocoris* sp.

At *Andropogon furcatus—Spartina Michauxiana* associes. Earliest adult, June 23, 1928; latest adult, Aug. 12, 1928. Most of the specimens were taken 1 mi. south of Amana. The species was most readily obtained at *Solidago canadensis* at the several stations.

*Ceratocapsus modestus* Uhl.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Aug. 4, 1927, one specimen.

*Lopidea media* Say

Taken on *Solidago* sp., 7.75 mi. northwest of Thompson, June 30, 1928, one specimen, and on *Solidago canadensis*, 1 mi. south of Amana, June 23, 1928, one specimen. Others seen.

*Lopidea minor* Knight

The author (1928) took this specimen at a *Stipa—Bouteloua* community, and found it showed a preference for *Pelatostemum purpureum.* Not taken elsewhere.

*Lopidea teton* Knight

At *Stipa spartea—Andropogon scoparius* association, where its food plant, *Astragalus caryocarpus,* was present, 7.75 mi. northwest of Thompson, June 30, 1928, one specimen. More seen.

*Lopidea incurva* Knight

Appeared to be feeding on flower bud of *Lepachys pinnata,* 1 mi. south of Amana, July 20, 1928. One specimen.

*Psallus* sp.

Swept from *Aster sericeus,* northeast of Iowa State College grounds, July 11, 1928. One of the specimens was observed to feed on *A. sericeus.* Numerous at this location. Two specimens, swept from *Amorpha canescens,* 1.5 mi. northeast of Ocheyedan, July 23, 1928. One specimen at *Andropogon scoparius—Bouteloua curtipendula* association, Sergeant Bluff, July 26, 1928.

*Plagiognathus politus* Uhl.

At all communities lower than *Bouteloua hirsuta—B. curtipendula.* Earliest adult June 23, 1928; latest adult Sept. 19, 1928. Most numerous at *Andropogon furcatus—Sorghastrum nutans* associes. Swept from flowers of *Anemone canadensis, Senecio aureus, Erigeron ramosus, Onosmodium occidentale, Rudbeckia hirta, Solidago* sp., and *Eupatorium* sp.

*Plagiognathus davisi* Knight

The author (1928) reported one specimen from a *Stipa—Bouteloua* community, but has not taken it elsewhere.

*Chlamydatus associatus* Uhl.

At *Andropogon scoparius—Bouteloua curtipendula* association, Gitchie-Manito State Park, July 24, 1928, two specimens. At *Stipa spartea —Andropogon scoparius association,* 5 mi. northwest of Buffalo Center, July 7, 1928, and Ocheyedan Mound, July 23, 1928. One specimen at each date. At *Polygonum amphibium* socies, 2 mi. west of Pacific Junction, July 31, 1928, one specimen.

*Ilnacora divisa* Reut.

At all communities except *Bouteloua hirsuta—B. curtipendula* association. Earliest adult, July 20, 1928, 1 mi. south of Amana, on *Helianthus grosseserratus;* latest adult, Aug. 24, 1928, 6 mi. south of Washington, swept from *Solidago Riddellii.* Taken at several stations on *Helianthus* sp., such as *occidentale* and *Maximiliani.* More readily obtained in western part of Iowa, where sunflowers are more generally distributed than elsewhere.

*Ilnacora stalii* Reut.

At *Andropogon furcatus—Spartina Michauxiana* associes. Earliest adult, July 14, 1926; latest adult, Aug. 24, 1928. Nearly all the specimens were swept from *Helianthus grosseserratus* and *H. Maximiliani.* Nymphs were seen on *H. grosseserratus,* 10 mi. southwest of Ames, July 14, 1928, where the species was numerous.

*Ilnacora* sp.

At *Andropogon scoparius—Bouteloua curtipendula association.* Nearly all the specimens were swept from *Dyssodia papposa,* July 24-31, 1928. Nymphs were seen on *D. papposa,* Gitchie-Manito State Park, July 24, 1928.

*Labopidea planifrons* Knight

At *Bouteloua hirsuta—B. curtipendula* association, 1.5 mi. northeast of Ocheyedan, July 23, 1928, one specimen.

*Reuteroscopus ornatus* Reut.

Swept from blooming *Cassia Chamaecrista,* 1 mi. south of Amana, Aug. 25, 1928, one specimen.

*Saldula major* Prov.

At *Polygonum amphibium* socies, .5 mi. south of Missouri Valley, Aug. 1, 1928, one specimen.

*Saldula interstitialis* Say

At *Spartina* consocies, 2.5 mi. south of Ames, May 30, 1927, Mar. 25, April 22, 1928. Four specimens.

*Micracanthia humeralis* Say

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, May 12, 1927. At *Spartina* consocies, May 30, June 5, 1927. Four specimens.

## ORDER HOMOPTERA

**The determinations of species were made by Drs. E. D. Ball, D. W. DeLong, P. B. Lawson, F. C. Hottes, and Messrs. Wm. T. Davis and G. S. Walley. The arrangement follows Van Duzee (1917), mainly.**

*Okanagana balli* Davis

At stands of *Andropogon furcatus,* chiefly. Earliest adult, June 26, 1926; latest adult, July 7, 1928. More specimens were obtained in 1928 than in the three previous years. Not numerous in 1928.

*Melampsalta calliope* Walk.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, July 6, 1928, two specimens. At *Andropogon furcatus—Sorghastrum nutans* associes, 1 mi. south of Amana, July 20, 1928, one specimen.

*Lepyronia quadrangularis* Say

At *Polygonum amphibium* socies, 10 mi. southwest of Kelso, July 30, 1928, one specimen. At *Andropogon furcatus—Sorghastrum nutans* associes, Lacey-Keosauqua State Park, Aug. 22, 1928, one specimen. At *Koeleria cristata,* 1.5 mi. northeast of Ocheyedan, July 23, 1928, one specimen.

*Lepyronia gibbosa* Ball

At *Andropogon furcatus* consocies, 8 mi. southeast of Britt, July 6, 1928; *Andropogon scoparius—Bouteloua curtipendula* association, 15 mi. north of Sioux City, July 26, 1928, and Council Bluffs, July 31, 1928; *Stipa spartea—Andropogon scoparius* association, 1.5 mi. northeast of Ocheyedan, July 23, 1928, and 7 mi. northwest of Thompson, June 30, 1928. Four of the five specimens are from the two higher communities.

*Philaronia bilineata* Say

At *Bouteloua hirsuta—B. curtipendula* association, closely pastured, Ocheyedan Mound, July 23, 1928, one specimen. At *Andropogon scoparius —Bouteloua curtipendula* association, 15 mi. north of Sioux City, July 26, 1928, four specimens.

*Ceresa diceros* Say

At *Spartina* consocies, 1 mi. south of Amana, Aug. 12, 1927, one specimen. Several seen, and one specimen collected from *Helianthus grosseserratus,* 1 mi. south of Amana, July 20, 1928. At *Andropogon furcatus* consocies, 6 mi. northwest of Cedar Falls, July 17, 1926, one specimen.

*Ceresa bubalus* Fab.

At *Andropogon furcatus—Spartina Michauxiana* associes. Earliest adult, July 16, 1928; latest adult, Aug. 25, 1928. Taken on *Solidago canadensis, Helianthus grosseserratus,* and most frequently at *Polygonum amphibium* socies, where it was, at times, common.

*Ceresa constans* Walk.

At *Andropogon scoparius—Bouteloua curtipendula* association, Sergeant Bluff, July 26, 1928, one specimen.

*Stictocephala inermis* Fabr.

At *Andropogon furcatus* communities, *Spartina* consocies, *Stipa spartea—Andropogon scoparius* association, and *Andropogon scoparius—Bouteloua curtipendula* association. Earliest adult, June 23, 1928; latest adult, Aug. 7, 1928. One nymph taken from *Solidago canadensis,* 1 mi. south of Amana, June 23, 1928. Adults swept from *Amorpha canescens, Helianthus* sp. and *Anemone canadensis.* Common at several communities.

*Stictocephala lutea* Walk.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, May 17, 1926, three specimens. At *Andropogon scoparius—Bouteloua curtipendula* association, 15 mi. north of Sioux City, July 26, 1928, one specimen. At *Stipa spartea—Andropogon scoparius* association, 7.75 mi. northwest of Thompson, May 18, June 30, 1928, two specimens.

*Acutalis tartarea* Say

At *Spartina* consocies, 6 mi. northwest of Cedar Falls, July 17, 1926, three specimens.

*Acutalis semicrema* Say

On *Helianthus grosseserratus*, 7.75 mi. northwest of Thompson, Aug. 6, 1928, five specimens.

*Micrutalis calva* Say

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Aug. 9, 1927, two specimens. On *Solidago* sp., 1 mi. south of Amana, June 23, Aug. 25, 1928, two specimens.

*Vanduzea triguttata* Burm.

At *Stipa spartea—Andropogon scoparius*, and *Andropogon scoparius—Bouteloua curtipendula* associations. Earliest adults, June 30, 1928; latest adult, Aug. 19, 1928. Taken on *Amorpha canescens* at several stations. Common where *A. canescens* occurred in good stands.

*Publilia concava* Say

On *Solidago canadensis*, *S. Riddellii*, and *Helianthus grosseserratus*, Aug. 24, 1928, Sept. 7, 1927. Not numerous.

*Publilia modesta* Uhl.

At *Stipa spartea—Andropogon scoparius* association, and *Andropogon scoparius—Bouteloua curtipendula* association. Reared from nymph on *Helianthus grosseserratus;* specimen labelled, 5 mi. south of Stanhope, Aug. 19, 1927. Moulted twice in twelve days. Taken from stems of *Solidago rigida*, 7.75 mi. northwest of Thompson, Aug. 6. 1928. Not numerous.

*Campylenchia latipes* Say

At all communities above *Spartina* consocies. Earliest adult, July 10, 1925; latest adult, Sept. 19, 1928. Common, and most numerous at *Stipa spartea—Andropogon scoparius* association.

*Enchenopa binotata* Say

At *Andropogon scoparius—Bouteloua curtipendula* association, swept from *Ceanothus americanus*, 4 mi. northeast of Beloit, July 25, 1928, three specimens.

*Agallia 4—punctata* Prov.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, June 23, 1926, one specimen.

*Agallia sanguinolenta* Prov.

At all communities. Earliest adult, 2.5 mi. south of Ames, Mar. 25, 1928; latest adult, Sept. 15, 1928. Numerous at *Stipa spartea—Andropogon scoparius* association, and less at other communities.

*Agallia uhleri* Van D.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Aug. 26, 1926, one specimen. At *Stipa spartea—Andropogon scoparius* association, 2.5 mi. north of Ames, Oct. 1, 1926, 7.75 mi. northwest of Thompson, two specimens.

*Agallia cinerea* O. & B.

At *Andropogon scoparius—Bouteloua curtipendula* association, July 25-30, 1928, scarce.

*Idiocerus alternatus* Fitch

At *Andropogon furcatus—Sorghastrum nutans* associes, 1.5 mi. northeast of Muscatine, Sept. 1, 1928, one specimen.

*Oncometopia lateralis* Fabr.

At *Andropogon scoparius—Bouteloua curtipendula* association, July 30, 31, 1928. Common at Hamburg State Park, July 30, 1928.

*Cicadella hieroglyphica* var. *dolobrata* Ball

On *Helianthus Maximiliani,* 10 mi. southwest of Kelso, several seen, one specimen taken July 30, 1928. At *Polygonum amphibium* socies, 2 mi. west of Pacific Junction, July 31, 1928, one specimen.

*Cicadella gothica* Sign.

Swept from *Solidago canadensis,* 6 mi. south of Washington, Aug. 24, 1928, one specimen.

*Helochara communis* Fitch

At *Spartina* consocies, 2.5 mi. south of Ames, May 12, 1927, one specimen.

*Graphocephala coccinea* Forst.

Swept from *Solidago canadensis,* 1 mi. south of Amana, at edge of wooded area, Aug. 25, 1928, four specimens.

*Draeculacephala mollipes* Say

At all communities. Earliest adult, June 15, 1928; latest adult, Sept. 19, 1928. Common at *Andropogon furcatus* consocies, *Andropogon furcatus —Sorghastrum nutans* associes, and *Stipa spartea—Andropogon scoparius* association. Scarce, usually at other communities.

*Draeculacephala noveboracensis* Fitch

At all communities except *Bouteloua hirsuta—B. curtipendula* association, and *Andropogon scoparius—Bouteloua curtipendula* association. Earliest adult, June 23, 1928; latest adult, Sept. 15, 1928. Most numerous at *Spartina* consocies.

*Gypona octolineata* Say

At *Andropogon scoparius—Bouteloua curtipendula* association, and *Stipa spartea—Andropogon scoparius* association. Earliest adult, July 26, 1928; latest adult, Aug. 7, 1928. Not numerous.

*Gypona octolineata* var. *striata* Burm.

At nearly all communities, but scarce. Earliest adult, July 23, 1928; latest adult, Aug. 12, 1927.

*Gypona melanota* Spangb.

At *Andropogon furcatus—Spartina Michauxiana* associes, *Stipa spartea—Andropogon scoparius* association, and *Andropogon scoparius—Bouteloua curtipendula* association. Most frequently taken at communities dominated by *Andropogon furcatus*. Earliest adult, July 10, 1925; latest adult, Aug. 22, 1925. Not numerous.

*Gypona unicolor* Stal

At *Andropogon scoparius—Bouteloua curtipendula* association, Oak Grove State Park, July 25, 1928, one specimen. At *Spartina* consocies, 7.75 mi. northwest of Thompson, Aug. 6, 1928, one specimen.

*Prairiana cinerea* Uhl.

At *Andropogon furcatus* consocies, 6 mi. northwest of Cedar Falls, July 17, 1926, one specimen. At *Stipa spartea—Andropogon scoparius* association, 3.5 mi. north of Ledyard, July 7, 1928, and 6 mi. northwest of Ledyard, Aug. 7, 1928, two specimens.

*Xerophloea viridis* Fabr.

At *Andropogon scoparius—Bouteloua curtipendula* association, July 26-31, 1928. Not numerous.

*Stroggylocephalus agrestis* Fall.

At *Spartina* consocies, 2.5 mi. north of Ames, May 7, 1928, one specimen.

*Xestocephalus pulicarius* Van D.

At *Stipa spartea—Andropogon scoparius* association, mown, 7.75 mi. northwest of Thompson, Sept. 15, 1928, one specimen.

*Dorycephalus platyrhynchus* Osborn

At *Andropogon furcatus—Spartina Michauxiana* associes, and *Stipa spartea—Andropogon scoparius* association. Adults, May 30-June 30. Nymphs, May 9-18; Aug. 6-Sept. 15. Not numerous, most of specimens from *Andropogon furcatus* consocies.

*Hecalus lineatus* Uhl.

At *Andropogon furcatus consocies,* 2.5 mi. south of Ames, July 10, 1925, one specimen. At *Spartina* consocies, 1 mi. south of Amana, Aug. 25, 1928, 7.75 mi. northwest of Thompson, Aug. 6, 1928, three specimens.

*Parabolocratus viridis* Uhl.

At all communities. Earliest adult, May 19, 1928; latest adult, Aug. 9, 1928. Common at *Stipa spartea—Andropogon scoparius* association.

*Parabolocratus major* Osborn

At *Spartina* consocies, 2.5 mi. south of Ames, June 26, 1926, Lake Amana, Aug. 12, 1927, two specimens. At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Aug. 14, 1925, one specimen. At *Stipa spartea—Andropogon scoparius* association, 5 mi. northwest of Buffalo Center, Aug. 6, 1928, one specimen.

*Parabolocratus flavidus* Sign.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, May 30, 1927, one male specimen.

*Mesamia nigridorsum* Ball

Taken on *Helianthus grosseserratus*, 2.5 mi. south of Ames, Aug. 14, 1925, and 10 mi. southwest of Ames, July 14, 1928. Two specimens at each date, and others seen on the sunflower plants.

*Scaphoideus immistus* Say

At *Spartina* consocies, 2.5 mi. north of Ames, Aug. 5, 1927, one specimen.

*Platymetopius acutus* Say

At all communities lower than *Bouteloua hirsuta—B. curtipendula* association. Earliest adult, June 23, 1928; latest adult, Sept. 19, 1928. Scarce at all communities.

*Platymetopius cinereus* O. & B.

At *Andropogon furcatus* consocies, *Andropogon furcatus—Sorghastrum nutans* associes, *Stipa spartea—Andropogon scoparius* association, and *Andropogon scoparius—Bouteloua curtipendula* association. Earliest adult, June 23, 1928; latest adult, Sept. 16, 1928. Not numerous at any community.

*Platymetopius frontalis* Van D.

At *Andropogon furcatus—Sorghastrum nutans* associes. Earliest adult, June 23, 1928; latest adult, Sept. 5, 1928. Nearly all specimens were swept from *Solidago canadensis*, at which it was common.

*Deltocephalus delector* S. & DeL.

At *Spartina* consocies, 1 mi. south of Amana, June 23, 1928, one specimen.

*Deltocephalus areolatus* Ball

At *Andropogon scoparius—Bouteloua curtipendula* association, Sergeant Bluff, July 26, 1928, one specimen.

*Deltocephalus albidus* O. & B.

At *Andropogon scoparius—Bouteloua curtipendula* association, 4 mi. northeast of Beloit, July 25, 1928, one specimen, and at *Stipa spartea—*

*Andropogon scoparius* association, 7.75 mi. northwest of Thompson, Aug. 6, 1928, one specimen.

*Deltocephalus sandersi* Osborn

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 16, Aug. 11, 1925, four specimens.

*Deltocephalus visendus* Crumb

At *Stipa spartea—Andropogon scoparius* association, 5 mi. northwest of Buffalo Center, Aug. 6, 1928, and 6 mi. northwest of Ledyard, Aug. 7, 1928. One specimen at each location.

*Deltocephalus reflexus* O. & B.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 10, Aug. 11, 25, 1925, three specimens. At *Stipa spartea—Bouteloua curtipendula* association, 2 mi. north of Ames, Oct. 9, 1926, one specimen.

*Deltocephalus pectinatus* O. & B.

At *Andropogon furcatus* consocies, 5 mi. northwest of Buffalo Center, Sept. 16, 1928, one specimen. At *Andropogon scoparius—Bouteloua curtipendula* association, 1 mi. west of Hamburg State Park, July 30, 1928, one specimen. At *Stipa spartea—Andropogon scoparius* association, 3.5 mi. north of Ledyard, Aug. 7, 1928, one specimen.

*Deltocephalus abbreviatus* O. & B.

At *Bouteloua hirsuta—B. curtipendula* association, Ocheyedan Mound, July 23, 1928, two specimens.

*Deltocephalus stylatus* Ball

At *Bouteloua hirsuta—B. curtipendula* association, Ocheyedan Mound, and 1.5 mi. northeast of Ocheyedan, July 23, 1928, five specimens. At *Andropogon scoparius—Bouteloua curtipendula* association, 4 mi. south of Westfield, July 26, 1928, one specimen.

*Deltocephalus configuratus* Uhl.

At all communities higher than *Spartina* consocies. Earliest adult, May 18, 1928; latest adult, Aug. 9, 1928. Numerous at *Stipa spartea—Andropogon scoparius* association. Less taken at other communities.

*Deltocephalus sayi* Fitch

At *Andropogon furcatus—Sorghastrum nutans* associes, 1 mi. south of Amana, June 23, Aug. 13, 1928. Not numerous.

*Deltocephalus inimicus* Say

At all communities lower than *Bouteloua hirsuta—B. curtipendula* association. Earliest adult, June 15, 1928; latest adult, Sept. 15, 1928. Numerous at *Andropogon furcatus* consocies, *Andropogon furcatus—Sorghastrum nutans* associes, and *Stipa spartea—Andropogon scoparius* association.

*Deltocephalus collinus* Boh.

At *Stipa spartea—Andropogon scoparius* association, 3.5 mi. north of Ledyard, Aug. 7, 1928, 6 mi. northwest of Ledyard, Aug. 6, 1928, and 7.75 mi. northwest of Thompson, Aug. 6, 1928. Scarce.

*Deltocephalus striatus* Linn.

At *Andropogon furcatus* consocies, 8 mi. southeast of Britt, Aug. 9, 1928, three specimens. At *Spartina* consocies, 6 mi. northwest of Ledyard, July 7, 1928, and .5 mi. south of Missouri Valley, Aug. 1, 1928. At *Andropogon scoparius—Bouteloua curtipendula* association, Oak Grove State Park, July 25, 1928. At *Stipa spartea—Andropogon scoparius* association, 5 mi. south of Stanhope, Aug. 10, 1927, Oct. 20, 1928. One to three specimens at each of the above mentioned communities.

*Deltocephalus unicoloratus* G. & B.

At *Andropogon furcatus* consocies, *Andropogon scoparius—Bouteloua curtipendula* association, and *Stipa spartea—Andropogon scoparius* association. Earliest adult, July 7, 1928; latest adult, Sept. 15, 1928. Not numerous.

*Deltocephalus paludosus* Ball

At *Carex* socies, 7.75 mi. northwest of Thompson, June 30, 1928, one specimen.

*Athysanella magdalena* Bak.

At *Stipa spartea—Andropogon scoparius* association, 6 mi. northwest of Ledyard, Aug. 7, 1928, five specimens. At *Bouteloua hirsuta—B. curtipendula* association, closely grazed, July 23, 1928, Ocheyedan Mound, one specimen.

*Driotura gammaroides* Van D.

At *Stipa spartea—Andropogon scoparius* association, 7.75 mi. northwest of Thompson, Aug. 6, 1928. At *Andropogon scoparius—Bouteloua curtipendula* association, Council Bluffs, July 31, 1928, and Sergeant Bluff, July 26, 1928. At *Andropogon furcatus* consocies, 3.5 mi. north of Ledyard, July 7, 1928, and 5 mi. east of Renwick, Aug. 9, 1928. One specimen at each date.

*Driotura gammaroides* var. *flava* O. & B.

At *Andropogon furcatus* consocies, 5 mi. east of Renwick, Aug. 9, 1928, 2.5 mi. south of Ames, Aug. 4, 1927. One specimen at each location.

*Driotura robusta* O. & B.

At *Andropogon scoparius—Bouteloua curtipendula* association, 4 mi. south of Westfield, Oak Grove State Park, Sergeant Bluff, July 25-26, 1928, four specimens. At *Stipa spartea—Andropogon scoparius* association, 1.5 mi. northeast of Ocheyedan, July 23, 1928, one specimen.

*Euscelis magnus* O. & B.

At *Andropogon furcatus—Spartina Michauxiana* associes, 2.5 mi. south of Ames, June 9, 1926, July 4, 1928, two specimens.

*Euscelis exitiosus* Uhl.

At *Andropogon furcatus* consocies, *Stipa spartea—Bouteloua curtipendula* association, and *Bouteloua hirsuta—B. curtipendula* association. Earliest adult, July 7, 1928; latest adult, Sept. 24, 1926. Not numerous.

*Euscelis striolus* Fall.

At *Andropogon furcatus* consocies, 8 mi. southeast of Britt, July 6, 1928, one specimen.

*Euscelis paralellus* Van D.

At *Stipa spartea—Andropogon scoparius* association, 6 mi. northwest of Ledyard, July 7, 1928, one specimen.

*Euscelis extrusus* Van D.

At *Stipa spartea—Andropogon scoparius* association, 7.75 mi. northwest of Thompson, June 30, 1928, two specimens.

*Euscelis obsoletus* Kirsch

At *Carex* socies, Lake Amana, June 23, 1928, one specimen. At *Stipa spartea—Andropogon scoparius* association, 7.75 mi. northwest of Thompson, June 30, 1928, one specimen.

*Euscelis anthracinus* Van D.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Aug. 17, 1926, April 24, 1927, three specimens. At *Andropogon scoparius—Bouteloua curtipendula* association, Council Bluffs, July 31, 1928, and Sergeant Bluff, July 26, 1928, four specimens.

*Euscelis striatulus* Fall.

At *Stipa spartea—Andropogon scoparius*, and *Andropogon scoparius—Bouteloua curtipendula* association, nearly all of the specimens. Earliest adult, July 23, 1928; latest adult, Aug. 19, 1927. Numerous.

*Euscelis comma* Van D.

At all communities except *Andropogon scoparius—Bouteloua curtipendula*, and *Bouteloua hirsuta—B. curtipendula* associations. Earliest adult, June 15, 1928; latest adult, Aug. 13, 1927. Not numerous.

*Euscelis colon* O. & B.

At *Stipa spartea—Andropogon scoparius* association, and *Andropogon scoparius—Bouteloua curtipendula* association. Earliest adult, June 30, 1928; latest adult, Aug. 9, 1928. Scarce.

*Euscelis curtisii* Fitch

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 10-Aug. 11, 1925, Aug. 26, 1926. At *Carex* socies, Lake Amana, June 23, 1928, one specimen. Not numerous at either station.

*Euscelis obtutus* Van D.

At *Andropogon furcatus* consocies, and *Stipa spartea—Andropogon scoparius* association. Earliest adult, April 16, 1927; latest adult, Sept. 17, 1926. Not numerous.

*Euscelis obscurinervis* Stal

At all communities above *Spartina* consocies except *Bouteloua hirsuta*—*B. curtipendula* association. Earliest adult, July 30, 1928; latest adult, Sept. 15, 1928. Scarce.

*Phlepsius areolatus* Bak.

At *Andropogon furcatus*—*Sorghastrum nutans* associes, 6 mi. south of Washington, Sept. 7, 1927, one specimen.

*Phlepsius altus* O. & B.

At *Andropogon scoparius*—*Bouteloua curtipendula* association, July 24-30, 1928, common. At *Bouteloua hirsuta*—*B. curtipendula* association, Ocheyedan Mound, and 1.5 mi. northeast of Ocheyedan, July 23, 1928, numerous. At *Stipa spartea*—*Andropogon scoparius* association, 5 mi. south of Stanhope, Aug. 5, 1927, and 7 mi. northwest of Thompson, Aug. 6, 1928, scarce.

*Phlepsius irroratus* Say

At all communities except *Bouteloua hirsuta*—*B. curtipendula,* and *Andropogon scoparius*—*Bouteloua curtipendula* associations. More specimens from *Polygonum amphibium* socies, 2.5 mi. south of Ames, than from any other community. Earliest adult, June 19, 1926; latest adult, Sept. 15, 1928.

*Phlepsius nebulosus* O. & B.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Aug. 4, 1925, one specimen.

*Phlepsius solidaginis* Walk.

At *Spartina* consocies, 2.5 mi. north of Ames, Aug. 5, 1927, two specimens.

*Dorydiella floridana* Bak.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 29, 31, 1925, two specimens.

*Thamnotettix melanogaster* Prov.

At *Carex* socies, chiefly. Earliest adult, June 26, 1926; latest adult, Sept. 15, 1928. Not numerous.

*Thamnotettix ciliatus* Osborn

At *Andropogon furcatus*—*Sorghastrum nutans* associes, 6 mi. south of Washington, Sept. 7, 1927, one specimen.

*Thamnotettix decipiens* Prov.

At *Polygonum amphibium* socies, 3.5 mi. north of Ledyard, July 7, 1928, one specimen.

*Thamnotettix fitchii* Van D.

At *Spartina* consocies, 1 mi. south of Amana, Aug. 13, 1927, one specimen.

*Chlorotettix unicolor* Fitch

At all communities higher than *Spartina* consocies. Earliest adult, June 23, 1928; latest adult, Sept. 7, 1927. More at *Stipa spartea—Andropogon scoparius* association than at any other community. Not numerous.

*Chlorotettix spatulatus* O. & B.

At all communities higher than *Spartina* consocies. Earliest adult, July 6, 1925; latest adult, Sept. 1, 1928. Most numerous at *Andropogon scoparius—Bouteloua curtipendula* association.

*Chlorotettix tergatus* Fh.

At *Spartina* consocies, 1 mi. south of Ames, Aug. 13, 1927, one specimen.

*Jassus olitorius* Say

At *Spartina* consocies, 1 mi. south of Amana, Aug. 13, 31, 1927; on *Solidago canadensis,* 1 mi. south of Amana, Aug. 25, 1928, two specimens. At *Andropogon furcatus—Sorghastrum nutans* associes, 6 mi. south of Washington, Sept. 7, 1927, one specimen.

*Cicadula sexnotata* Fall.

At all communities except *Bouteloua hirsuta—B. curtipendula* association, and *Andropogon scoparius—B. curtipendula* association. Earliest adult, May 9, 1926; latest adult, Sept. 15, 1928. Most numerous at *Andropogon furcatus* consocies.

*Eugnathodus abdominalis* Van D.

At *Andropogon scoparius—Bouteloua curtipendula* association, 4 mi. northeast of Beloit, July 25, 1928, and Sergeant Bluff, July 26, 1928. At *Stipa spartea—Andropogon scoparius* association, 6 mi. northwest of Ledyard, Aug. 7, 1928. At *Andropogon furcatus—Sorghastrum nutans* associes, 1.5 mi. east of Muscatine, Sept. 1, 1928. Scarce.

*Dikraneura fieberi* Loew

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Aug. 25, 1925. At *Polygonum amphibium* socies, 2.5 mi. south of Ames, June 26, 1926. At *Spartina* consocies, 5 mi. east of Renwick, Aug. 9, 1928. At *Stipa spartea—Andropogon scoparius* association, 7.75 mi. northwest of Thompson, June 30, Sept. 15, 1928. Scarce.

*Empoasca obtusa* Walsh

At *Andropogon furcatus—Sorghastrum nutans* associes, 1 mi. south of Amana, June 23, 1928, two specimens, and 6 mi. south of Washington, Sept. 7, 1928, one specimen.

*Empoasca flavescens* Fabr.

Swept from *Rudbeckia hirta,* 1 mi. south of Amana, June 23, 1928, one specimen.

*Empoasca fabae* Harr.

At *Andropogon scoparius—Bouteloua curtipendula* association, Oak Grove State Park, July 25, 1928. At *Stipa spartea—Andropogon scoparius* association, 5 mi. south of Stanhope, June 15, 1928. On *Helianthus grosseserratus*, 7.75 mi. northwest of Thompson, Aug. 6, 1928. Scarçe.

*Scolops sulcipes* Say

At all communities higher than *Spartina* consocies. Most numerous at *Stipa spartea—Andropogon scoparius* association. Earliest adult, June 23, 1928; latest adult, Sept. 19, 1928.

*Scolops osborni* Ball

At *Andropogon scoparius—Bouteloua curtipendula* association, 4 mi. northeast of Beloit, July 25, 1928, two specimens, and Gitchie-Manito State Park, July 24, 1928, two specimens.

*Scolops spurcus* Uhl.

At *Andropogon scoparius—Bouteloua curtipendula* association, Gitchie-Manito State Park, July 24, 1928, two specimens.

*Scolops vanduzei* Ball

At *Andropogon scoparius—Bouteloua curtipendula* associtaion, 15 mi. north of Sioux City, July 26, 1928, one specimen.

*Scolops angustatus* Uhl.

At all communities higher than *Spartina* consocies except *Andropogon furcatus—Sorghastrum nutans* associes. Earliest adult, July 11, 1928; latest adult, Aug. 7, 1928. Most numerous at *Bouteloua hirsuta—B. curtipendula* association, at Ocheyedan Mound, and 1.5 mi. northeast of Ocheyedan, and at *Andropogon scoparius—Bouteloua curtipendula* association, several stations.

*Scolops pungens* Germ.

At *Andropogon scoparius—Bouteloua curtipendula* association, July 24-Aug. 1, 1928, at stations from Council Bluffs to Gitchie-Manito Park. Common at several stations.

*Phylloscelis pallescens* Germ.

At *Andropogon furcatus—Sorghastrum nutans* associes, 6 mi. south of Washington, Sept. 7, 1927, one specimen.

*Oliarus complectus* Ball

At *Andropogon furcatus—Spartina Michauxiana* associes, 2.5 mi. south of Ames, July 15, 1926, and Aug. 4, 1927, two specimens.

*Oliarus humilis* Say

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 10-31, 1925, four specimens. At *Spartina* consocies, 2.5 mi. south of Ames, June 26, 1928, one specimen.

*Cixius basalis* V. D.

At *Spartina* consocies and *Carex* socies, 7.75 mi. northwest of Thompson, Sept. 15, 1928, two specimens.

*Cixius stigmatus* Say

At *Spartina* consocies, 2.5 mi. south of Ames, June 26, 1926, one specimen.

*Bruchomorpha oculata* Newm.

At *Stipa spartea—Andropogon scoparius* association, northeast of Iowa State College grounds, July 11, 1928, one specimen, and 5 mi. south of Stanhope, Oct. 20, 1928, one specimen.

*Bruchomorpha dorsata* Fitch

At all communities except *Bouteloua hirsuta—B. curtipendula*. Earliest adult, June 23, 1926; latest adult, Sept. 15, 1928. Largest number taken at one station was from *Andropogon scoparius—Bouteloua curtipendula* association, July 26, 1928, 4 mi. south of Westfield. Not numerous at any station.

*Aphelonema histrionica* Stal

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, June 25, Aug. 17, 26, 1926, five specimens. At *Spartina* consocies, 2.5 mi. south of Ames, July 11, 1928, one specimen.

*Aphelonema bivittata* Ball

At *Andropogon scoparius—Bouteloua curtipendula* association, 15 mi. north of Sioux City, July 26, 1928, one specimen.

*Aphelonema simplex* Uhl.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 17, 1926, two specimens. At *Andropogon furcatus—Sorghastrum nutans* associes, 1 mi. south of Amana, June 23, Aug. 25, 1928, five specimens

*Acanalonia bivittata* Say

At *Andropogon scoparius—Bouteloua curtipendula* association, several stations, July 25-31, 1928. At *Spartina* consocies, 10 mi. southwest of Kelso, July 30, 1928. At *Andropogon furcatus—Sorghastrum nutans* associes at earliest date, Aug. 12, 1928, and latest date, Sept. 7, 1927. Found at stations bordered by woods or shrubs most frequently, but not numerous.

*Ormenis pruinosa* Say

At *Andropogon scoparius—Bouteloua curtipendula* association, July 26-Aug. 1, 1928. Not numerous. At *Andropogon furcatus—Sorghastrum nutans* associes, 6 mi. south of Washington, Sept. 7, 1927, one specimen.

*Cedusa vulgaris* Fh.

At *Carex* socies, 7.75 mi. northwest of Thompson, Sept. 15, 1928, two specimens.

*Herpis obscura* Ball

At *Carex* socies, 10 mi. southwest of Kelso, July 30, 1928, 7.75 mi. northwest of Thompson, Sept. 15, 1928, three specimens. Swept from *Amorpha canescens*, 1 mi. south of Amana, July 20, 1928, two specimens.

*Stenocranus dorsalis* Fitch

At *Spartina* consocies, 2.5 mi. south of Ames, April 26, 1926, two specimens, May 12, 1927, one specimen, and March 25, 1928, one specimen.

*Stenocranus vittatus* Stal

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Aug. 4, 1927, one specimen.

*Kelisia crocea* Van D.

At *Andropogon furcatus—Spartina Michauxiana* associes, and *Stipa spartea—Andropogon scoparius* association. Earliest adult, June 23, 1928; latest adult, Sept. 15, 1928. Not numerous at any station, but more were taken at *Spartina* consocies than at any other community.

*Pissonotus delicatus* Van D.

At *Andropogon scoparius—Bouteloua curtipendula* association, July 25-31, 1928. Most frequent on *Dyssodia papposa,* Oak Grove State Park, July 25, 1928.

*Stobaera tricarinata* Say

At *Stipa spartea—Bouteloua curtipendula* association, 2 mi. north of Ames, Oct. 1, 1926, one specimen. At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Apr. 5, 12, May 21, 1926; one specimen on each date. At *Bouteloua hirsuta—B. curtipendula* association, 5 mi. south of Stanhope, Oct. 20, 1928, two specimens.

*Liburnia* near *osborni* V. D.

At *Andropogon furcatus—Spartina Michauxiana* associes, chiefly. Earliest adult, May 18, 1926; latest adult, Sept. 15, 1928. Most frequent at *Spartina* consocies.

*Livia vernalis* Fitch

At *Spartina* consocies, 2.5 mi. south of Ames, May 12, 1927, one specimen. At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, July 11, 1928, one specimen.

*Aphalara calthae* Linn.

At *Carex* socies, chiefly. Earliest adult, May 18, 1928; latest adult, Sept. 15, 1928. Not numerous.

*Aphalara veaziei* Patch

On *Solidago canadensis, S. missouriensis.* Earliest adult, July 11, 1928; latest adult, Aug. 25, 1928, several stations.

*Anoecia corni* Fab.

At *Stipa spartea—Andropogon scoparius* association, 5 mi. south of Stanhope, Sept. 19, 1928.

*Bipersona torticauda* Gill.

On *Cirsium iowense,* 5 mi. northwest of Buffalo Center, Aug. 6, 1928.

*Hyalopterus arundinis* Fab.

On *Phragmites communis,* 5 mi. northwest of Buffalo Center, Aug. 6, 1928, one specimen.

*Tritogenaphis* (?) *rudbeckiae* Fitch

On *Solidago rigida,* 7 mi. northwest of Thompson, June 30, 1928; on *Lepachys pinnata,* 1 mi. south of Amana, July 20, 1928.

*Tritogenaphis* sp.

On *Helianthus grosseserratus,* 2.5 mi. south of Ames, Aug. 18, 1927.

## ORDER COLEOPTERA

Most of the species have been determined by Prof. H. F. Wickham, Drs. L. L. Buchanan and G. M. Stirrett, and Messrs. W. J. Brown, K. F. Chamberlain, N. K. Bigelow (assisted by Chas. W. Leng), Chas. Schaeffer, and M. C. Lane. A few determinations were made by the author in common species. The arrangement follows Leng (1920).

*Cicindela punctulata* Oliv.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 11, 1928, one specimen. At *Bouteloua hirsuta—B. curtipendula* association, Ocheyedan Mound, July 23, 1928, 5 mi. south of Stanhope, Aug. 19, 1927, Aug. 9, 1928, one specimen at each date, and several seen. On rocks, and over bare places around rocks, *Andropogon scoparius—B. curtipendula* association, Gitchie-Manito State Park, July 24, 1928, several specimens of this species, probably, were seen.

*Calosoma calidum* Fab.

At *Spartina* consocies, under debris, 2.5 mi. north of Ames, Aug. 5, 1927, one specimen.

*Scarites subterraneus* var. *substriatus* Hald.

At *Spartina* consocies, subterranean, 1 mi. south of Gruver, July 8, 1928, one specimen.

*Dyschirius globulosus* Say

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, April 21, 1926, one specimen. At *Andropogon furcatus* consocies, 8 mi. southeast of Britt, May 19, 1928, seven specimens.

*Bembidion variegatum* Say

At *Spartina* consocies, 2.5 mi. south of Ames, June 5, 1927, one specimen, and 8 mi. southeast of Britt, May 19, 1928, three specimens.

*Bembidion affine* Say

At *Spartina* consocies, 2.5 mi. south of Ames, Mar. 25, 1928, one specimen, and at *Andropogon furcatus* consocies, 5 mi. east of Renwick, May 19, 1928, one specimen.

*Bembidion frontale* Lec.

At *Spartina* consocies, 2.5 mi. north of Ames, May 2, 1928, one specimen, and 8 mi. southeast of Britt, May 19, 1928, three specimens.

*Tachys incurva* Say

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, July 8, 1925, one specimen. At *Spartina* consocies, 8 mi. southeast of Britt, May 19, 1928, one specimen, and at *Andropogon furcatus* consocies, same locality and date.

*Tachyura vivax* Lec.

At *Andropogon furcatus* consocies, 8 mi. southeast of Britt, July 6, 1928, one specimen.

*Eumolops sodalis* Lec.

Under stones, *Stipa spartea—Andropogon scoparius* association, 5 mi. south of Stanhope, Apr. 25, 1928, and 2 mi. north of Ames, May 7, 1928. Five specimens.

*Eumolops colossus* Lec.

At *Spartina* consocies, under debris, and subterranean, 2.5 mi. south of Ames, July 18, 1926, 2.5 mi. north of Ames, July 6, 1928, and 1 mi. south of Gruver, July 8, 1928. Four specimens.

*Abacidus permundus* Say

At *Spartina* consocies, under debris, 2.5 mi. north of Ames, May 2, 1928, one specimen.

*Poecilus chalcites* Say

At *Spartina* consocies, 2.5 mi. north of Ames, May 2, 1928, one specimen, under debris.

*Poecilus lucublandus* Say

At *Spartina* consocies, under debris, 2.5 mi. north of Ames, May 2, 1928, two specimens.

*Omaseus luctuosus* Dej.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Mar. 18, 1927, one specimen.

*Micromaseus patruelis* Dej.

At *Spartina* consocies, 8 mi. southeast of Britt, May 19, 1928, one specimen.

*Amara impuncticollis* Say

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, May 30, 1926, one specimen.

*Triaena pallipes* Kby.

At *Spartina* consocies, 2.5 mi. south of Ames, June 26, 1926, one specimen. On *Lespedeza capitata,* 2 mi. north of Ames, June 24, 1926, one specimen taken, several others seen.

*Triaena angustata* Say

At *Andropogon furcatus—Spartina Michauxiana* associes. Earliest adult, May 2, 1928; latest adult, July 6, 1928. Numerous at *Andropogon furcatus—Sorghastrum nutans* associes, 1 mi. south of Amana, June 23, 1928.

*Rembus expansa* Csy.

At *Spartina* consocies, 2.5 mi. south of Ames, May 21, June 5, 1927, two specimens.

*Rembus laticollis* Lec.

At *Spartina* consocies, 2.5 mi. north of Ames, May 2, 1928, one specimen, under debris.

*Platynus decorus* Say

At *Polygonum amphibium* socies, 2.5 mi. south of Ames, June 26, 1926, one specimen.

*Platynus atratus* Lec.

At *Spartina* consocies, under debris, 2.5 mi. north of Ames, May 2, 1928, one specimen.

*Platynus placidus* Say

At *Stipa spartea—Andropogon scoparius* association, 5 mi. south of Stanhope, Aug. 19, 1927, one specimen.

*Platynus aeruginosus* Dej.

At *Spartina* consocies, 8 mi. southeast of Britt, Aug. 9, 1928, one specimen.

*Platynus lutulentus* Lec.

At *Andropogon furcatus* consocies, 8 mi. southeast of Britt, July 6, 1928, one specimen.

*Leptotrachelus dorsalis* Fab.

At *Spartina* consocies, Lake Amana, Aug. 12, 31, 1927, two specimens.

*Galerita janus* Fab.

At *Spartina* consocies, under debris, 2.5 mi. north of Ames, May 7, 1928, one specimen.

*Lebia atriventris* Say

At *Andropogon furcatus—Spartina Michauxiana* associes. Earliest adult, Aug. 5, 1927; latest adult, Aug. 25, 1928. Not numerous.

*Lebia viridis* Say

At all communities. Earliest adult, May 12, 1927; latest adult, Aug. 13, 1927. Most of the species were taken at *Spartina* consocies, where it is a common ground beetle.

*Lebia pumila* Dej.

At all communities lower than *Bouteloua hirsuta—B. curtipendula* association. Earliest adult, May 9, 1928; latest adult, Aug. 12, 1927. More specimens taken at *Andropogon furcatus—Spartina Michauxiana* associes than at any other community, and common at that community.

*Lebia pleuritica* Lec.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, May 26, 1926, one specimen. At *Spartina* consocies, 1 mi. south of Amana, Aug. 12, 1927, and Gitchie-Manito State Park, July 24, 1928, two specimens.

*Lebia viridipennis* Dej.

At *Spartina* consocies, 1 mi. south of Amana, Aug. 25, 1928, one specimen.

*Lebia scapularis* Dej.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, May 21, 1926, and 6 mi. northwest of Cedar Falls, July 17, 1926, two specimens. At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, May 30, 1926, and 7.75 mi. northwest of Thompson, June 30, 1928, two specimens. At *Andropogon scoparius—Bouteloua curtipendula* association, Sergeant Bluff, July 26, 1928, one specimen.

*Calleida punctata* Lec.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 20, 1925, one specimen. At *Spartina* consocies, earliest adult, Aug. 2, 1926, and latest adult, Aug. 31, 1927. Common at *Spartina* consocies.

*Cymindis pilosa* Say

At *Bouteloua hirsuta—B. curtipendula* association, closely grazed, Ocheyedan Mound, July 23, 1928, one specimen.

*Brachinus perplexus* Dej.

At *Spartina* consocies, 2.5 mi. south of Ames, June 5, 1927, and 2.5 mi. north of Ames, July 16, 1928, two specimens.

*Chlaenius diffinis* Chaud.

At *Spartina* consocies, 2.5 mi. north of Ames, May 7, 1928, one specimen. At *Stipa spartea—Andropogon scoparius* association, 5 mi. south of Stanhope, Apr. 25, 1928, one specimen under a stone.

*Chlaenius laticollis* Say

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Apr. 25, 1927, two specimens, under stones.

*Chlaenius sericeus* Forst.

At *Spartina* consocies, under debris, 2.5 mi. north of Ames, May 7, 1928, one specimen.

*Harpalus erraticus* Say.

At *Andropogon scoparius—Bouteloua curtipendula* association, Gitchie-Manito State Park, July 24, 1928, one specimen, on the ground.

*Harpalus compar* Lec.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Aug. 9, 16, 1926. Both specimens were taken at night.

*Harpalus pennsylvanicus* De G.

At *Stipa spartea—Andropogon scoparius* association, 5 mi. south of Stanhope, May 9, 1928, one specimen, under a stone.

*Harpalus pleuriticus* Kby.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, May 7, 1928, and 5 mi. south of Stanhope, May 9, 1928, two specimens, under stones. At *Spartina* consocies, subterranean, 1 mi. south of Gruver, six specimens, 2.5 mi. south of Ames, Apr. 22, 1928, one specimen, and 2.5 mi. north of Ames, under debris, May 2, 1928, one specimen. Common at *Spartina* consocies.

*Harpalus herbivagus* Say

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, May 31, June 22, 1926, two specimens, 5 mi. south of Stanhope, under stones, Apr. 25, Oct. 20, 1928, two specimens, and June 15, 1928, one specimen taken by sweeping. At *Spartina* consocies under debris, 2.5 mi. north of Ames, May 2, 1928, one specimen.

*Triplectrus rusticus* Say

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Apr. 25, 1928, one specimen, under stone. At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, June 28, July 15, 1928, two specimens.

*Pseudamphasia sericea* Harr.

At *Andropogon furcatus—Spartina Michauxiana* associes. Earliest adult, June 23, 1926; latest adult, July 15, 1928. Probably more numerous at *Spartina* consocies than at any other community, and there the species is common.

*Stenolophus conjunctus* Say

Nearly all of the specimens were taken at *Andropogon furcatus—Spartina Michauxiana* associes. The species was common at *Andropogon furcatus* consocies in early spring, but when standing water has disappeared from *Spartina* consocies the species was prevalent there. Earliest adult, Apr. 12, 1928; latest adult, Sept. 15, 1928.

*Tachistodes partiarius* Say

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, June 26, 1928, one specimen.

*Agonoderus pallipes* Fab.

At nearly all communities. Earliest adult, April 22, 1928; latest adult, June 30, 1928. Not numerous.

*Silpha inaequalis* Fab.

Under dead cottontail rabbit, 5 mi. south of Stanhope, May 5, 1928, one specimen.

*Choleva basillaris* Say

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Apr. 26, 1926, one specimen.

*Stenus flavicornis* Er.

At *Spartina* consocies, 2.5 mi. south of Ames, June 5, 1927, one specimen.

*Xantholinus emmesus* Grav.

At *Stipa spartea—Andropogon scoparius* association, 5 mi. south of Stanhope, Oct. 20, 1928, one specimen, under stone.

*Tachyporus scitulus* Er.

At *Carex* socies, 1 mi. south of Amana, June 23, 1928, two specimens.

*Hister americanus* Payk.

At *Andropogon furcatus—Spartina Michauxiana* associes, and *Stipa spartea—Andropogon scoparius* association. Earliest adult, March 25, 1928, under stone; latest adult, May 20, 1927. Not numerous.

*Platysoma lecontei* Mars.

At *Stipa spartea—Andropogon scoparius* association, 5 mi. northwest Buffalo Center, May 18, 1929, several specimens.

*Lucidota nigricans* Say

Nearly all specimens taken at *Spartina* consocies, and *Andropogon furcatus* consocies. Earliest adult, May 19, 1928; latest adult, July 30, 1928. Common at *Andropogon furcatus* consocies, and *Spartina* consocies.

*Lucidota indicta* Lec.

At *Spartina* consocies and *Carex* socies. Earliest adult, June 23, 1928; latest adult, July 17, 1928. Not numerous, one to two at each of several stations.

*Pyractomena angulata* Say

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, June 5, 1926, one specimen, and at *Carex* socies, 1 mi. south of Amana, June 23, 1928, one specimen.

*Chauliognathus pennsylvanicus* De G.

At all communities. Earliest adult, July 24, 1928; latest adult, Sept. 19, 1928. Common at *Stipa spartea—Andropogon scoparius* association, and *Andropogon furcatus* consocies where herbaceous plants are more numerous. The species is most numerous at flowers of *Compositae* such as *Solidago* spp. and *Helianthus* spp.

*Podabrus tomentosus* Say

At *Andropogon furcatus* consocies. Earliest adult, May 31, 1926; latest adult, July 6, 1928. Not common.

*Cantharis tantillus* Lec.

At *Andropogon furcatus—Spartina Michauxiana* associes, and *Stipa spartea—Andropogon scoparius* association. Earliest adult, May 21, 1927; latest adult, June 30, 1928. Not numerous at any station, but probably more common at *Spartina* consocies than at any other community.

*Cantharis carolinus* Fab.

At *Andropogon furcatus—Spartina Michauxiana* associes. Earliest adult, May 25, 1926; latest adult, June 30, 1928. Not numerous at any community.

*Cantharis rectus* Melsh.

At *Spartina* consocies, 2.5 mi. south of Ames, May 30, 1927, one specimen.

*Cantharis flavipes* Lec.

At *Carex* socies, 1 mi. south of Amana, June 23, 1928, one specimen.

*Cantharis luteicollis* Germ.

At *Spartina* consocies, Lake Amana, June 23, 1928, four specimens, and 2.5 mi. south of Ames, May 30, 1927, two specimens. At *Carex* socies, 7.75 mi. northwest of Thompson, June 30, 1928, one specimen.

*Cantharis simpliunguis* Blatch.

At *Spartina* consocies, 2.5 mi. south of Ames, May 20, 1927, two specimens. At *Andropogon furcatus* consocies, 5 mi. east of Renwick, May 19, 1928, three specimens.

*Ditemnus bidentatus* Say

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 29, 31, 1925, and May 11, 21, 1926. Four specimens.

*Silis latilobus* Blatch.

At *Andropogon furcatus—Spartina Michauxiana* associes. Earliest adult, May 19, 1928; latest adult, Aug. 13, 1927. Most of the specimens are from *Spartina* consocies, but not numerous at any station.

*Trypherus latipennis* Germ.

Swept from flowers of *Rudbeckia hirta*, 1 mi. south of Amana, June 23, 1928, one specimen, and from flowers of *Anemone canadense*, same locality and date, one specimen.

*Collops tricolor* Say

At *Andropogon scoparius—Bouteloua curtipendula* association, July 24-26, 1928. Common.

*Collops sublimbatus* Schaeff.

At *Andropogon scoparius—Bouteloua curtipendula* association, July 26-30, 1928. Scarce.

*Collops quadrimaculatus* Fab.

At *Andropogon furcatus—Spartina Michauxiana* associes. Earliest adult, June 23, 1928; latest adult, Aug. 26, 1926. Most numerous at *Andropogon furcatus* consocies, where it is common.

*Trichodes nutalli* Kby.

At *Andropogon scoparius—Bouteloua curtipendula* association, Oak Grove State Park, July 25, 1928, one specimen.

*Hydnocera lecontei* Wolc.

At all communities. Earliest adult, June 23, 1928; latest adult, Aug. 26, 1926. Not common at any community.

*Hydnocera tricondylae* Lec.

At *Andropogon furcatus* consocies, and *Stipa spartea—Andropogon scoparius* association. Earliest adult, July 6, 1928; latest adult, Aug. 9, 1928. Not common at either community.

*Rhipiphorus dimidiatus* Fab.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 16, 1925, one specimen.

*Epicauta trichrus* Pall.

At *Stipa spartea—Andropogon scoparius* association, 5 mi. northwest of Buffalo Center, July 7, 1928, and 7.75 mi. northwest of Thompson, June 30, 1928. Six specimens. At *Andropogon furcatus* consocies, 5 mi. east of Renwick, Aug. 9, 1928, one specimen. Common at *Stipa spartea—Andropogon scoparius* association.

*Epicauta sericans* Lec.

At *Andropogon scoparius—Bouteloua curtipendula* association, 4 mi. south of Westfield, July 26, 1928, one specimen, and Sergeant Bluff, July 26, 1928, two specimens.

*Epicauta lemniscata* Fab.

At *Spartina* consocies, Lake Amana, Aug. 12, 1927, two specimens.

*Epicauta cinerea* Forst.

At *Bouteloua hirsuta—B. curtipendula* association, Ocheyedan Mound, July 23, 1928, one specimen. At *Stipa spartea—Andropogon scoparius* association, 7.75 mi. northwest of Thompson, June 30, 1928, three specimens. At *Andropogon scoparius—Bouteloua curtipendula* association, Oak Grove State Park, July 25, 1928, and Gitchie-Manito State Park, July 24, 1928, two specimens.

*Epicauta marginata* Fab.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Aug. 17, 1926, one specimen.

*Epicauta pennsylvanica* De G.

At all communities higher than *Spartina* consocies, and lower than *Bouteloua hirsuta—B. curtipendula* association. Earliest adult, July 24, 1928; latest adult, Sept. 5, 1928. Numerous at *Stipa spartea—Bouteloua curtipendula* association, and *Andropogon furcatus* consocies where *Compositae,* in blossom, were common. *Solidago* spp. appeared to be most attractive to this most common blister beetle.

*Macrobasis unicolor* Kby.

At *Amorpha canescens,* 1.5 mi. northeast of Ocheyedan, July 23, 1928, one specimen.

*Nemognatha sparsa* Lec.

At flower of *Dyssodia papposa,* Oak Grove State Park, July 25, 1928, two specimens.

*Notoxus anchora* Hentz

At *Andropogon furcatus—Spartina Michauxiana* associes. Earliest adult, June 9, 1926; latest adult, July 7, 1928. Scarce.

*Notoxus monodon* Fab.

At *Bouteloua hirsuta—B. curtipendula* association, 5 mi. south of Stanhope, Oct. 20, 1928, one specimen.

*Anthicus formicarius* Laf.

At *Andropogon furcatus* consocies. Earliest adult, Apr. 12, 1926; latest adult, Aug. 17, 1926. Scarce.

*Anthicus cervinus* Laf.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Apr. 12, 1926, one specimen.

*Anthicus lutulentus* Csy.

At *Spartina* consocies, 2.5 mi. south of Ames, May 5, 1926, one specimen.

*Lacon rectangularis* Say

At *Andropogon scoparius—Bouteloua curtipendula* association, Oak Grove State Park, July 25, 1928, one specimen, and under stone at *Stipa spartea—Andropogon scoparius* association, 5 mi. south of Stanhope, May 9, 1928, one specimen.

*Monocrepidius vespertinus* Fab.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Aug. 16, 1926, and at *Spartina* consocies, 10 mi. southwest of Kelso, July 30, 1928.

*Monocrepidius auritus* Hbst.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, June 19, 1926, one specimen. At *Stipa spartea—Andropogon scoparius* association, 5 mi. south of Stanhope, Aug. 5, 1927, one specimen. At *Andropogon scoparius—Bouteloua curtipendula* association, Gitchie-Manito State Park, July 24, 1928, two specimens.

*Drasterius elegans* Fab.

At *Spartina* consocies, 2.5 mi. south of Ames, May 12, 1926. At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Apr. 25, 1927, one specimen, and 5 mi. south of Stanhope, May 9, 1928, one specimen, under stone.

*Limonius propexus* Cand.

At *Andropogon furcatus—Spartina Michauxiana* associes, and *Stipa spartea—Andropogon scoparius* association. Earliest adult, May 9, 1928; latest adult, July 6, 1928. A common click beetle of which most specimens have come from *Andropogon furcatus* consocies.

*Ludius inflatus* Say

At *Andropogon furcatus—Spartina Michauxiana* associes, 2.5 mi. south of Ames, May 28, 29, 1926, and June 5, 1927. Three specimens.

*Hemicrepidius memnonius* Hbst.

At *Spartina* consocies, subterranean, 1 mi. south of Gruver, July 8, 1928, one specimen.

*Hemicrepidius bilobatus* Say

At *Spartina* consocies, subterranean, 1 mi. south of Gruver, July 8, 1928, one specimen.

*Cryptohypnus abbreviatus* Say

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Apr. 30, 1926, one specimen.

*Oedostethus femoralis* Lec.

At *Carex* socies, 1 mi. south of Amana, June 23, 1928, three specimens. At *Stipa spartea—Bouteloua curtipendula* association, 5 mi. south of Stanhope, June 15, 1928, one specimen.

*Agriotes oblongicollis* Melsh.

At *Stipa spartea—Andropogon scoparius* association, 7.75 mi. northwest of Thompson, June 30, 1928, one specimen.

*Melanotus cribulosus* Lec.

At *Andropogon furcatus* consocies, and *Spartina* consocies. Earliest adult, May 26, 1926; latest adult, Aug. 5, 1927. A common click beetle at *Andropogon furcatus* consocies.

*Acmaeodera pulchella* Hbst.

At flowers of *Rudbeckia hirta*, 5 mi. east of Renwick, July 8, 1928, and at several species of *Compositae* flowers, 2.5 mi. south of Ames, July 10, 1928.

*Agrilus lacustris* Lec.

At *Andropogon scoparius—Bouteloua curtipendula* association, Council Bluffs, July 31, 1928, one specimen.

*Pachyschelus purpureus* Say

On *Desmodium illinoense* leaves, 2.5 mi. south of Ames, July 20, 1925, one specimen, and 6 mi. northwest of Ledyard, July 7, 1928, one specimen. At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 10, 1925, one specimen.

*Taphrocerus gracilis* Say

At *Spartina* consocies, 2.5 mi. south of Ames, May 21, 1927, and Lake Amana, Aug. 12, 1927. Two specimens.

*Ptilodactyla serricollis* Say

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, June 23, 1926, two specimens.

*Dermestes caninus* Germ.

Under dead jackrabbit, Ocheyedan Mound, July 23, 1928, two specimens.

*Brachypterus urticae* Fab.

At *Stipa spartea—Andropogon scoparius* association, northeast of Iowa State College grounds, July 11, 1928, one specimen.

*Conotelus obscurus* Er.

In flowers of *Convolvulus sepium,* 1 mi. south of Amana, July 20, 1928, three specimens.

*Carpophilus dimidiatus* Fab.

Swept from *Amorpha canescens,* 1.5 mi. northeast of Ocheyedan, July 23, 1928, one specimen.

*Carpophilus brachypterus* Say

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Apr. 9, 1928, in *Anemone patens* var. *Wolfgangiana* flower, one specimen. At *Andropogon scoparius—Bouteloua curtipendula* association, Gitchie-Manito State Park, July 24, 1928, one specimen. At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, earliest adult, Apr. 26, 1926, and latest adult, July 10, 1926. Common at the last community.

*Carpophilus antiquus* Melsh.

At *Spartina* consocies, Lake Amana, June 23, 1928, two specimens.

*Epuraea rufa* Say

At *Spartina* consocies, 2.5 mi. south of Ames, May 12, 1927, one specimen.

*Glischrochilus fasciatus* Oliv.

At *Pedicularis canadensis,* blooming, 2.5 mi. south of Ames, May 17, 1926, one specimen. At *Andropogon furcatus* consocies, same locality, May 20, 1927, one specimen.

*Telephanus velox* Hald.

At *Spartina* consocies, Lake Amana, Aug. 12, 1927, one specimen.

*Languria bicolor* Fab.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, June 23, 26, 1926, two specimens.

*Languria mozardi* Latr.

At *Andropogon furcatus—Spartina Michauxiana* associes. Earliest adult, Apr. 16, 1927; latest adult, Aug. 17, 1926. Common at *Andropogon furcatus* consocies.

*Atomaria ephippiata* Zimm.

At *Andropogon furcatus* consocies, 8 mi. southeast of Britt, May 19, 1928, one specimen.

*Typhaea fumata* Linn.

At *Stipa spartea—Andropogon scoparius* association, 7.75 mi. northwest of Thompson, June 30, 1928, one specimen.

*Phalacrus simplex* Lec.

At *Andropogon furcatus—Spartina Michauxiana* associes, and *Stipa spartea—Andropogon scoparius* association. Earliest adult, May 18, 1928; latest adult, July 23, 1928. Scarce.

*Phalacrus politus* Melsh.

At *Andropogon furcatus—Spartina Michauxiana* associes, and *Stipa spartea—Andropogon scoparius* association. Earliest adult, May 19, 1928; latest adult, Sept. 19, 1928. At flowers of *Elymus virginicus*, 1 mi. south of Amana, Aug. 13, 1927. Common.

*Olibrus semistriatus* Lec.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, May 12, 1927, one specimen.

*Olibrus pallipes* Say

At *Andropogon scoparius—Bouteloua curtipendula* association, Gitchie-Manito State Park, July 24, 1928, one specimen.

*Stilbus apicalis* Melsh.

At *Spartina* consocies, .5 mi. south of Missouri Valley, Aug. 1, 1928, one specimen.

*Scymnus americanus* Muls.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Aug. 17, 1926, one specimen.

*Hyperaspis undulata* Say

At nearly all communities lower than *Bouteloua hirsuta—B. curtipendula* association. Earliest adult, May 7, 1928; latest adult, Aug. 9, 1928. Common at *Andropogon furcatus* consocies.

*Coccidula lepida* Lec.

At *Spartina* consocies. Earliest adult, May 18, 1928; latest adult, June 23, 1928. Common.

*Anisosticta strigata* Thunb.

At *Spartina* consocies, 4 mi. northwest of Thompson, May 18, 1928, one specimen.

*Macronaemia episcopalis* Kby.

At *Spartina* consocies, 4 mi. northwest of Thompson, May 18, 1928, one specimen.

*Megilla maculata* De G.

At *Spartina* consocies, chiefly. Earliest adult, May 5, 1926. Latest adult, Oct. 20, 1928, at *Stipa spartea—Bouteloua curtipendula* association, 5 mi. south of Stanhope. Common at *Spartina* consocies.

*Hippodamia tredecim-punctata* Linn.

At all communities. Earliest adult, May 7, 1928; latest adult, Oct. 20, 1928. Common.

*Hippodamia parenthesis* Say

At all communities. Earliest adult, May 2, 1928; latest adult, Oct. 20, 1928. Common.

*Hippodamia glacialis* Fabr.

At *Andropogon furcatus—Sorghastrum nutans* associes, 1 mi. south of Amana, June 23, 1928, two specimens. At *Andropogon furcatus* consocies, 6 miles northwest of Cedar Falls, July 17, 1926, one specimen, and 3.5 mi. north of Ledyard, July 7, Aug. 7, 1928, two specimens. At *Andropogon scoparius—Bouteloua curtipendula* association, Gicthie-Manito State Park, July 24, 1928.

*Hippodamia convergens* Guer.

At all communities lower than *Bouteloua hirsuta—B. curtipendula* association. Earliest adult, June 30, 1928; latest adult, Sept. 7. 1928. Common.

*Coccinella trifasciata* Linn.

At *Elymus virginicus,* 1 mi. south of Amana, Aug. 12, 1927, one specimen. At *Stipa spartea—Andropogon scoparius* association, Ocheyedan Mound, July 23, 1928, two specimens.

*Coccinella novemnotata* Hbst.

At all communities lower than *Bouteloua hirsuta—B. curtipendula* association. Earliest adult, May 20, 1927; latest adult, Aug. 25, 1928. Common.

*Coccinella sanguinea* Linn.

At all communities lower than *Bouteloua hirsuta—B. curtipendula* association. Earliest adult, July 11, 1928; latest adult, Sept. 7, 1928. Common at *Andropogon furcatus* consocies, and *Andropogon furcatus—Sorghastrum nutans* associes.

*Eleodes tricostata* Say

At *Andropogon scoparius—Bouteloua curtipendula* association, 1 mi. north of Reels City, Aug. 1, 1928, one specimen.

*Ptinus brunneus* Dufts.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Mar. 25, 1928, one specimen.

*Canthon laevis* Dru.

At *Stipa spartea—Andropogon scoparius* association, 5 mi. south of Stanhope, May 9, 1928, one specimen under a stone.

*Onthophagus hecate* Panz.

At *Andropogon furcatus—Spartina Michauxiana* associes, and *Stipa spartea—Andropogon scoparius* association. Earliest adult, May 9, 1928; latest adult, Aug. 7, 1925. Under dead cottontail rabbit, 5 mi. south of Stanhope, May 9, 1928, four specimens. Not numerous.

*Aphodius fimetarius* Linn.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Apr. 16, 1927, one specimen.

*Aphodius distinctus* Mull.

At all communities except *Andropogon scoparius—Bouteloua curtipendula* association. Earliest adult, Mar. 25, 1928; latest adult, Oct. 20, 1928. Common.

*Aphodius alternatus* Horn

At *Andropogon furcatus* consocies, 2 mi. south of Ledyard, May 9, 1926, four specimens. At *Spartina* consocies, 4 mi. northwest of Thompson, May 18, 1928, and 8 mi. southeast of Britt, May 19, 1928, two specimens.

*Aphodius socialis* Brown

At *Stipa spartea—Andropogon scoparius* association, 5 mi. south of Stanhope, Oct. 20, 1928, one specimen.

*Ataenius cognatus* Lec.

At *Spartina* consocies, 2.5 mi. south of Ames, May 12, 1927, one specimen.

*Bolbocerosoma farctum* Fab.

At *Andropogon furcatus—Spartina Michauxiana* associes, 2.5 mi. south of Ames, June 25, 1925, and June 23, 26, 1926. Three specimens.

*Serica* sp.

At *Stipa spartea—Andropogon scoparius* association. Earliest adult, June 30, 1928; latest adult, July 7, 1928. Common at *Amorpha canescens*, 7.75 mi. northwest of Thompson, June 30, 1928.

*Phyllophaga* sp.

At *Spartina* consocies, subterranean, 2 mi. west of Kelso, July 30, 1928, one specimen.

*Anomala innuba* Fab.

Swept from *Apocynum androsaemifolium*, 1 mi. south of Amana, June 23, 1928, two specimens.

*Ligyrodes relictus* Say

At *Spartina* consocies, subterranean, 1 mi. south of Gruver, July 8, 1928, four specimens, 10 mi. southwest of Kelso, July 30, 1928, one specimen, and 2 mi. west of Kelso, July 30, 1928, one specimen.

*Ligyrus gibbosus* De G.

At *Stipa spartea—Andropogon scoparius* association, 5 mi. south of Stanhope, March 25, 1928, one specimen, under stone.

*Euphoria inda* Linn.

At *Spartina* consocies, 2.5 mi. south of Ames, Mar. 17, 1928, one specimen.

*Typocerus confluens* Csy.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 20, 1928, two specimens.

*Typocerus sinuatus* Newm.

At *Andropogon furcatus* consocies, and *Andropogon scoparius—Bouteloua curtipendula* association. Earliest adult, July 7, 1928; latest adult, Aug. 7, 1928. Common at flowers of *Compositae* of *Andropogon furcatus* consocies.

*Mecas saturnina* Lec.

Swept from *Lepachys pinnata*, 2.5 mi. south of Ames, July 15, 1928, one specimen.

*Oberea tripunctata* Swed.

At *Andropogon furcatus—Sorghastrum nutans* associes, 1 mi. south of Amana, July 20, 1928, one specimen.

*Tetraopes tetrophthalmus iowensis* Csy.

At *Andropogon furcatus—Spartina Michauxiana* associes, 2.5 mi. south of Ames, July 6, Aug. 26, 1926, three specimens on *Asclepias* sp. At *Carex* socies, Lake Amana, July 23, 1928, one specimen.

*Tetraopes femoratus amnicola* Csy.

At *Andropogon scoparius—Bouteloua curtipendula* association, Oak Grove State Park, and 4 mi. northeast of Beloit, July 25, 1928, four specimens. At *Stipa spartea—Andropogon scoparius* association, Ocheyedan Mound, July 23, 1928, one specimen.

*Lema brunnicollis* Lac.

At *Stipa spartea—Andropogon scoparius* association, 7.75 mi. northwest of Thompson, June 30, 1928, one specimen.

*Lema collaris* Say

Cut out of stems of *Tradescantia reflexa*, 1 mi. south of Amana, July 20, 1928, two specimens which had emerged from puparia within stems. Several other pupae were found in the stems.

*Lema trilineata* Oliv.

At *Stipa spartea—Andropogon scoparius* association, northeast of Iowa State College grounds, July 11, 1928, one specimen, and at *Andropogon furcatus* consocies, 2 mi. south of Ledyard, May 9, 1926, one specimen.

*Antipus laticlavia* Forst.

At *Stipa spartea—Andropogon scoparius* association. Earliest adult, June 15, 1928; latest adult, June 30, 1928. Common on *Amorpha canescens*, 7.75 mi. northwest of Thompson, June 30, 1928.

*Coscinoptera dominicana* Fab.

At *Stipa spartea—Andropogon scoparius* association, 7.75 mi. northwest of Thompson, June 30, 1928, one specimen.

*Coscinoptera* near *axillaris* Lec.

At *Andropogon scoparius—Bouteloua curtipendula* association, 15 mi. north of Sioux City, July 26, 1928, one specimen.

*Babia quadriguttata* Oliv.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, June 1, 1926, one specimen.

*Pachybrachys spumarius* Suffr.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 16, 1925, one specimen.

*Pachybrachys othonus* Say

At all communities except *Bouteloua hirsuta—B. curtipendula* association. Earliest adult, June 5, 1926; latest adult, July 30, 1928. Not numerous at any station.

*Pachybrachys m-nigrum* Melsh.

At *Andropogon furcatus—Sorghastrum nutans* associes, 1 mi. south of Amana, June 23, 1928, one specimen.

*Pachybrachys luridus* Fab.

At *Stipa spartea—Andropogon scoparius* association, 5 mi. south of Stanhope, June 15, 1928, five specimens, of which two were taken on *Amorpha canescens.*

*Monachulus ater* Hald.

At *Andropogon furcatus* consocies, 8 mi. southeast of Britt, July 6, 1928, one specimen.

*Monachus saponatus* Fab.

At *Spartina* consocies, and *Carex* socies, chiefly. Earliest adult, June 30, 1927; latest adult, Aug. 5, 1927. Not common.

*Cryptocephalus leucomelas* Suffr.

At *Andropogon furcatus—Sorghastrum nutans* associes, 1 mi. south of Amana, July 20, 1928, one specimen.

*Cryptocephalus venustus* Fab.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 10, 1925, and July 2, 1926, two specimens. At *Andropogon furcatus—Sorghastrum nutans* associes, 1 mi. south of Amana, June 23, 1928, two specimens.

*Cryptocephalus venustus cinctipennis* Rand.

At *Andropogon furcatus—Spartina Michauxiana* associes. *Andropogon furcatus—Sorghastrum nutans* associes, and *Stipa spartea—Andropogon scoparius* association. Earliest adult, June 5, 1928; latest adult, Aug. 14, 1925. Not numerous.

*Cryptocephalus venustus hamatus* Melsh.

At *Andropogon furcatus—Spartina Michauxiana* associes, *Andropogon furcatus—Sorghastrum nutans* associes, and *Stipa spartea—Andropogon scoparius* association. Earliest adult, June 23, 1928; latest adult, July 29, 1925. Not numerous.

*Cryptocephalus incertus* Hald.

Swept from *Senecio aureus,* 1 mi. south of Amana, June 23, 1928, one specimen. At *Andropogon furcatus* consocies, 8 mi. southeast of Britt, July 6, 1928, one specimen. Swept from *Psoralea argophylla,* 5 mi. northwest of Buffalo Center, July 7, 1928, one specimen. At *Andropogon scoparius—Bouteloua curtipendula* association, Gitchie-Manito State Park, July 24, 1928, and Oak Grove State Park, July 25, 1928, two specimens.

*Cryptocephalus calidus* Suffr.

Feeding on leaflet of *Amorpha canescens,* 1 mi. south of Amana, July 20, 1928, one specimen. On *Helianthus grosseserratus,* same locality, Aug. 12, 1927, several specimens. At *Andropogon furcatus* consocies, earliest adult, July 7, 1928, and latest adult, Aug. 9, 1928. At *Stipa spartea—Andropogon scoparius* association, 1.5 mi. northeast of Ocheyedan, July 23, 1928, and 7.75 mi. northwest of Thompson, two specimens. Not numerous.

*Bassareus lituratus* var. *recurvus* Say

At *Andropogon furcatus—Spartina Michauxiana* associes, 2.5 mi. south of Ames, May 21, 1926, June 5, 1927, two specimens.

*Nodonota tristis* Oliv.

At *Andropogon furcatus—Sorghastrum nutans* associes, 1 mi. south of Amana, June 23, 1928. At *Stipa spartea—Andropogon scoparius* association, earliest adult, June 30, 1928, and latest adult, July 23, 1928. Common at *Andropogon scoparius—Bouteloua curtipendula* association, July 24-26, 1928.

*Nodonota clypealis* Horn

At *Polygonum amphibium* socies, 10 mi. southwest of Kelso, July 30, 1928, one specimen.

*Nodonota convexa* Say

At *Andropogon furcatus—Spartina Michauxiana* associes, *Andropogon furcatus—Sorghastrum nutans* associes, and *Stipa spartea—Andropogon scoparius* association. Earliest adult, June 26, 1926; latest adult Aug. 12, 1928. Most numerous at flowers of *Zizia aurea* and *Erigeron ramosus,* 1 mi. south of Amana, June 23, 1928.

*Nodonota puncticollis* Say

At *Andropogon furcatus* consocies, and *Stipa spartea—Andropogon scoparius* association. Earliest adult, June 1, 1926; latest adult, July 23, 1928. Most numerous on *Amorpha canescens,* 7.75 mi. northwest of Thompson, June 30, 1928.

*Colaspis brunnea* Fab.

At all communities higher than *Spartina* consocies. Earliest adult, July 7, 1928; latest adult, Aug. 26, 1928. One adult fed on leaf of *Helianthus grosseserratus,* 1 mi. south of Amana, Aug. 13, 1927. Numerous on *Aster multiflorus,* 1.5 mi. northeast of Ocheyedan, July 23, 1928.

*Colaspis favosa* Say

At *Andropogon furcatus—Spartina Michauxiana* associes. Earliest adult, June 23, 1928; latest adult, Aug. 26, 1926. Most numerous at *Spar-*

*tina* consocies, and *Polygonum amphibium* socies. An adult was observed feeding on a leaf of *Polygonum amphibium,* 2.5 mi. south of Amana, July 13, 1926.

*Rhabdopterus picipes* Oliv.

At *Andropogon furcatus—Spartina Michauxiana* associes. Earliest adult, June 23, 1926; latest adult, Aug. 12, 1927. Not common.

*Graphops varians* Lec.

At *Stipa spartea—Andropogon scoparius* association, and *Andropogon scoparius—Bouteloua curtipendula* association. Common at the latter association. Earliest adult, July 7, 1928; latest adult, Aug. 6, 1928.

*Graphops pubescens* Melsh.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, May 21, 1926, one specimen. Four specimens that were feeding on leaves of *Oenothera biennis* were taken 2.5 mi. south of Ames, June 5, 1926. At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Apr. 12, 1927, one specimen.

*Graphops curtipennis* Melsh.

At *Andropogon furcatus* consocies, and *Stipa spartea—Andropogon scoparius* association. Earliest adult, May 9 ,1928; latest adult, Oct. 20, 1928. Common.

*Graphops marcassitus* Cr.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Aug. 9, 1926, one specimen, and 3.5 mi. north of Ledyard, Aug. 7, 1928, one specimen.

*Metachroma interruptum* Say

On *Helianthus grosseserratus,* Lake Amana, June 23, 1928, one specimen.

*Myochrous squamosus* Lec.

At *Andropogon scoparius—Bouteloua curtipendula* association, Council Bluffs, July 31, 1928, one specimen.

*Paria canella* Fab.

At *Spartina* consocies, 2.5 mi. south of Ames, May 5, 1926, two specimens.

*Paria canella aterrima* Oliv.

At *Andropogon furcatus—Spartina Michauxiana* associes, *Andropogon furcatus—Sorghastrum nutans* associes, and *Stipa spartea—Andropogon scoparius* association. Earliest adult, June 23, 1928; latest adult, Aug. 13, 1927. Common at *Andropogon furcatus—Sorghastrum nutans* associes, and *Spartina* consocies, 1 mi. south of Amana.

*Paria canella* var. near *pumila* Lec.

At *Spartina* consocies, 8 mi. southeast of Britt, May 19, 1928, one specimen.

*Paria canella quadriguttata* Lec.

Swept from *Anemone canadensis,* 1 mi. south of Amana, June 23, 1928, one specimen.

*Paria canella quadrinotata* Say

At *Stipa spartea—Andropogon scoparius* association, and *Andropogon furcatus—Spartina Michauxiana* associes. Earliest adult, May 9, 1926; latest adult, July 10, 1928. Not numerous at any community but probably more frequent at *Spartina* consocies than at any other community.

*Paria canella sellata* Horn

At *Andropogon furcatus—Sorghastrum nutans* associes, 1 mi. south of Amana, June 23, 1928, eight specimens.

*Paria canella sexnotata* Say

At *Spartina* consocies, 2.5 mi. south of Ames, May 30, 1927, one specimen.

*Chrysochus auratus* Fab.

On *Apocynum androsaemifolium,* 2.5 mi. south of Ames, numerous. Earliest adult, July 22, 1925; latest adult, Aug. 11, 1925. At *Andropogon furcatus—Sorghastrum nutans* associes, 1 mi. south of Amana, June 23, 1928, one specimen.

*Prasocuris vittata* Oliv.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, May 12, 1927, one specimen.

*Labidomera clivicollis* var. *rogersi* Lec.

Swept from *Elymus virginicus,* 1 mi. south of Amana, Aug. 13, 1927, two specimens.

*Zygogramma suturalis* Fab.

At *Spartina* consocies, 1 mi. south of Amana, Aug. 13, 1927, one specimen.

*Zygogramma suturalis* var. *casta* Rog.

At *Andropogon scoparius—Bouteloua curtipendula* association, Gitchie-Manito State Park, July 24, 1928, three specimens. On flower of *Lepachys pinnata,* 5 mi. south of Stanhope, Aug. 5, 1927, one specimen.

*Calligrapha similis* Rog.

At *Spartina* consocies, 1 mi. south of Amana, and Lake Amana, Aug. 12, 13, 1927, three specimens.

*Calligrapha praecelsis* Rog.

At *Spartina* consocies, Lake Amana, June 23, 1928, one specimen.

*Phaedon viridis* Melsh.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, May 12, 1927, one specimen.

*Gastroidea dissimilis* Say

At *Polygonum amphibium* socies, .5 mi. south of Missouri Valley, Aug. 1, 1928, three specimens.

*Lina scripta* Fab.

At *Andropogon scoparius—Bouteloua curtipendula* association, Council Bluffs, July 31, 1928, one specimen.

*Trirhabda virgata* Lec.

At all communities. Earliest adult, July 7, 1928; latest adult, Sept. 19, 1928. Numerous on *Helianthus* spp. and *Solidago* spp. feeding on leaves.

*Galerucella americana* Fab.

At *Andropogon furcatus* consocies, *Stipa spartea—Andropogon scoparius* association, and *Andropogon scoparius—Bouteloua curtipendula* association. Earliest adult, June 30, 1928; latest adult, Aug. 9, 1928. Not common at any station.

*Galerucella conferta* Lec.

At *Spartina* consocies, Lake Amana, Aug. 12, 1927, June 23, 1928, five specimens. At *Carex* socies, 7.75 mi. northwest of Thompson, June 30, 1928, one specimen.

*Galerucella cribrata* Lec.

At *Stipa spartea—Andropogon scoparius* association, chiefly. Earliest adult, June 30, 1928; latest adult, Aug. 20, 1928. Not numerous.

*Galerucella decora* Say

At *Andropogon scoparius*, 7.75 mi. northwest of Thompson, June 30, 1928, one specimen, and *Carex* socies, same locality and date, one specimen.

*Diabrotica duodecimpunctata* Fabr.

At all communities except *Andropogon scoparius—Bouteloua curtipendula* association. Earliest adult, May 21, 1927; latest adult, Sept. 19, 1928. Common at flowers of *Compositae*, especially in August and September.

*Diabrotica longicornis* Say

At all communities except *Andropogon scoparius—Bouteloua curtipendula* association. Earliest adult, Aug. 14, 1926; latest adult, Oct. 20, 1928. Numerous at flowers of *Compositae*, August and September.

*Diabrotica atripennis fossata* Lec.

At *Polygonum amphibium* socies, 2.5 mi. south of Ames, July 22-Aug. 9, 1926, common, feeding on leaves of *P. amphibium*. At *Andropogon scoparius—Bouteloua curtipendula* association, Sergeant Bluff, July 26, 1928, two specimens.

*Diabrotica vittata* Fab.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, May 21, 1926, one specimen.

*Phyllobrotica decorata* Say

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, May 30, 1926, and 6 mi. northwest of Cedar Falls, July 17, 1926. At *Spartina* consocies, Lake Amana, June 23, 1928. At *Stipa spartea—Andropogon scoparius* association, 7.75 mi. northwest of Thompson, June 30, 1928. One specimen on each date.

*Phyllobrotica limbata* Fab.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, June 19, 26, 1926, two specimens.

*Cerotoma trifurcata* Forst.

At *Andropogon furcatus* consocies, and *Spartina* consocies. Earliest adult, June 23, 1926; latest adult, Aug. 12, 1927. Scarce.

*Hypolampsis pilosa* Ill.

At *Stipa spartea—Andropogon scoparius* association, 6 mi. northwest of Ledyard, Aug. 7, 1928, one specimen.

*Oedionychis gibbitarsa* Say.

At *Spartina* consocies, under debris, 2.5 mi. north of Ames, May 2, 1928.

*Oedionychis miniata* Fab.

At *Andropogon scoparius—Bouteloua curtipendula* association, 15 mi. north of Sioux City, July 26, 1928, three specimens.

*Oedionychis thyamoides* Cr.

At *Andropogon furcatus—Spartina Michauxiana* associes, *Andropogon furcatus—Sorghastrum nutans* associes, and *Stipa spartea—Andropogon scoparius* association. Earliest adult, May 8, 1926; latest adult, Sept. 7, 1927. One adult was seen feeding on leaf of *Silphium laciniatum,* 2.5 mi. south of Ames, May 19, 1926. Not numerous.

*Oedionychis limbalis* Melsh.

At *Spartina* consocies, 4 mi. northwest of Thompson, May 18, 1928, and at *Andropogon furcatus* consocies, 5 mi. east of Renwick, May 19, 1928, one specimen.

*Disonycha triangularis* Say

At *Polygonum amphibium* socies, 2.5 mi. south of Ames, Aug. 2, 1926, and 10 mi. southwest of Kelso, two specimens. At *Stipa spartea—Andropogon scoparius* association, 1.5 mi. northwest of Ocheyedan, July 23, 1928, one specimen.

*Disonycha xanthomelaena* Dalm.

At *Andropogon furcatus* consocies, and *Andropogon scoparius—Bouteloua curtipendula* association. Earliest adult, Apr. 24, 1927; latest adult, July 31, 1928. Scarce.

*Haltica litigata* Fall

At *Spartina* consocies, 2.5 mi. south of Ames, May 30-June 5, 1927. Not numerous.

*Haltica foliacea* Lec.

At *Spartina* consocies, 2.5 mi. south of Ames, June 26, 1926, one specimen.

*Chalcoides fulvicornis nana* Say

At *Spartina* consocies, and *Carex* socies. Earliest adult, June 30, 1928; latest adult, Sept. 15, 1928. Common at *Spartina* consocies, 7.75 mi. northwest of Thompson, Sept. 15, 1928.

*Epitrix fuscula* Cr.

At *Spartina* consocies, 2.5 mi. south of Ames, May 30, 1927, one specimen. At *Andropogon scoparius—Bouteloua curtipendula* association, Council Bluffs, July 31, 1928, one specimen.

*Epitrix parvula* Fab.

Swept from blooming *Rosa pratincola* 1 mi. south of Amana, June 23, 1928, one specimen.

*Chaetocnema denticulata* Ill.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 10, 29, 1925, two specimens.

*Chaetocnema opulenta* (?) Horn

At *Andropogon furcatus* consocies, 6 mi. northwest of Le Mars, July 26, 1928, one specimen.

*Systena frontalis* Fab.

At *Polygonum amphibium* consocies, earliest adult, July 26, 1926; latest adult, Sept. 16, 1928. Common. At *Andropogon scoparius—Bouteloua curtipendula* association, Sergeant Bluff, July 26, 1928, one specimen.

*Systena elongata* Fab.

At *Andropogon furcatus* consocies, chiefly. Earliest adult, Aug. 6, 1928; latest adult, Sept. 15, 1928. Common.

*Longitarsus testaceus* Melsh.

At *Andropogon furcatus—Spartina Michauxiana* associes. Earliest adult, Apr. 26, 1926; latest adult, Aug. 11, 1925. Common. In flower of *Pedicularis canadensis,* 2.5 mi. south of Amana, May 12, 1926, one specimen.

*Glyptina spuria* Lec.

At *Andropogon furcatus—Spartina Michauxiana* associes, and *Stipa spartea—Andropogon scoparius* association. Earliest adult, Mar. 25, 1928; latest adult, Sept. 15, 1928. Not numerous.

*Phyllotreta zimmermanni* Cr.

At *Spartina* consocies, Lake Amana, June 23, 1928, one specimen, and 8 mi. southeast of Britt, May 19, 1928, one specimen.

*Phyllotreta vittata* Fab.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 10, 1925, one specimen, and June 22, 1926, one specimen.

*Phyllotreta bipustulata* Fab.

At *Andropogon furcatus—Spartina Michauxiana* associes. Earliest adult, Apr. 22, 1928; latest adult, Aug. 31, 1927. Not numerous.

*Psylliodes punctulata* Melsh.

At *Andropogon furcatus—Spartina Michauxiana* associes, and *Stipa spartea—Bouteloua curtipendula* association. Earliest adult, Mar. 25, 1928; latest adult, Aug. 9, 1928. Common.

*Stenispa metallica* Fab.

At *Spartina* consocies and *Carex* socies, Lake Amana, June 23, Aug. 31, 1928, three specimens.

*Microrhopala vittata* Fabr.

At *Andropogon furcatus* consocies, and *Andropogon scoparius—Bouteloua curtipendula* association. Earliest adult, May 5, 1926; latest adult, Aug. 26, 1925. Larvae, leaf miners of *Silphium laciniatum*, were frequently seen. Common where *S. laciniatum* occurs in families as at 2.5 mi. south of Ames.

*Chelymorpha cassidea* Fab.

At *Andropogon furcatus—Sorghastrum nutans* associes, 1 mi. south of Amana, July 20, Aug. 25, 1928, two specimens. At *Andropogon scoparius—Bouteloua curtipendula* association, Gitchie-Manito State Park, July 24, 1928, two specimens.

*Jonthonota nigripes* Oliv.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Aug. 19, 1925, and June 1, 1926, two specimens.

*Chirida guttata* Oliv.

At *Andropogon scoparius—Bouteloua curtipendula* association, *Andropogon furcatus—Sorghastrum nutans* associes, *Spartina* consocies, and *Carex* socies. Earliest adult, July 20, 1928; latest adult, Aug. 13, 1927. Not numerous.

*Metriona bivittata* Say

At *Andropogon furcatus—Spartina Michauxiana* associes. Earliest adult, May 9, 1926; latest adult, Aug. 17, 1926. Scarce.

*Metriona bicolor* Fab.

At *Andropogon furcatus—Sorghastrum nutans* associes, and *Andropogon furcatus* consocies. Earliest adult, June 18, 1925; latest adult, Sept. 16, 1928. Not numerous.

*Bruchus cruentatus* Horn

At *Polygonum amphibium* socies, 10 mi. southwest of Kelso, July 30, 1928, three specimens.

*Bruchus fraterculus* Horn

At *Stipa spartea—Andropogon scoparius* association, and *Andropogon scoparius—Bouteloua curtipendula* association. Earliest adult, June 30, 1928; latest adult, Aug. 6, 1928. Common at the first mentioned association.

*Bruchus musculus* Say

At *Andropogon furcatus* consocies. Earliest adult, June 30, 1928; latest adult, Aug. 9, 1928. Not numerous.

*Bruchus seminulum* Horn

At *Andropogon scoparius—Bouteloua curtipendula* association, 1 mi. west of Hamburg State Park to Sergeant Bluff, July 26, 30, 1928, three specimens.

*Brachytarsus sticticus* Boh.

At *Andropogon furcatus—Spartina Michauxiana* associes. Earliest adult, Apr. 30, 1926; latest adult, May 30, 1927. Common. Numerous at *Elymus virginicus*, 1 mi. south of Amana, Aug. 13, 1927.

*Brachytarsus tomentosus* Say

At *Stipa spartea—Andropogon scoparius* association, 3.5 mi. north of Ledyard, Aug. 7, 1928, one specimen.

*Rhynchites bicolor* Fab.

At *Rosa pratincola* flowers, 1 mi. south of Amana, June 23, 1928, 5 mi. south of Stanhope, June 15, 1928, and 7.75 mi. northwest of Thompson, June 30, 1928. Common at several stations.

*Rhynchites aeneus* Boh.

At *Andropogon scoparius—Bouteloua curtipendula* association, Sergeant Bluff, July 26, 1926, one specimen.

*Apion pennsylvanicum* Boh.

At *Andropogon furcatus—Sorghastrum nutans* associes, 6 mi. south of Washington, Sept. 7, 1927, one adult.

*Apion tenuirostrum* Smith

At *Andropogon furcatus* consocies, and *Stipa spartea—Andropogon scoparius* association. Earliest adult, May 19, 1928; latest adult, July 23, 1928. Not numerous.

*Apion griseum* Smith

At *Andropogon furcatus—Spartina Michauxiana* associes, and *Stipa spartea—Andropogon scoparius* association. Earliest adult, May 9, 1926; latest adult, July 30, 1928. Not numerous.

*Apion varicorne* Smith

At *Andropogon furcatus* consocies, *Andropogon scoparius—Bouteloua curtipendula* association, and *Stipa spartea—Andropogon scoparius* association. Earliest adult, May 19, 1928; latest adult, Sept. 15, 1928. Common at *Stipa spartea—Andropogon scoparius* association, 7.75 mi. northwest of Thompson, Aug. 6, 1928.

*Apion* sp. 1

At *Andropogon furcatus—Sorghastrum nutans* associes, 6 mi. south of Washington, Sept. 7, 1927, one specimen.

*Apion* sp. 2

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Apr. 16, 1927, four specimens.

*Apion* sp. 3

At *Andropogon furcatus—Spartina Michauxiana* associes, and *Stipa spartea—Andropogon scoparius* association. Earliest adult, May 19, 1928; latest adult, Sept. 15, 1928. Six specimens.

*Apion* sp. 4

At *Andropogon furcatus—Spartina Michauxiana* associes. Earliest adult, Apr. 12, 1926; latest adult, July 22, 1925. Six specimens.

*Anametis granulata* Say

At *Stipa spartea—Andropogon scoparius* association, 5 mi. south of Stanhope, earliest date, Apr. 25, 1928, and latest date, Aug. 19, 1927. Swept from *Amorpha canescens*, 7.75 mi. northwest of Thompson, June 30, 1928, one specimen, and from *Helianthus occidentale*, 5 mi. south of Stanhope, Aug. 19, 1927. Numerous 5 mi. south of Stanhope, May 9, 1928.

*Tanymecus confertus* Gyll.

At *Spartina* consocies, Lake Amana, Aug. 12, 1927, one specimen.

*Mesagroicus minor* Buch. (MS)

At *Andropogon furcatus—Spartina Michauxiana* associes, 2.5 mi. south of Amana, May 20, 1927, and June 26, 1926. At *Stipa spartea—Andropogon scoparius* association, 5 mi. south of Stanhope, June 15, 1928. Three specimens, in total. This is a new species named by L. L. Buchanan, and was in manuscript at the time of return of the specimens, December, 1928.

*Graphorhinus vadosus* Say

At *Andropogon scoparius—Bouteloua curtipendula* association, Oak Grove State Park, July 25, 1928, one specimen.

*Epicaerus imbricatus* Say

Swept from *Elymus virginicus*, 1 mi. south of Amana, Aug. 12, 1927, one specimen, and *Andropogon furcatus*, 1.5 mi. east of Verdi, Aug. 20, 1928, one specimen. At *Stipa spartea—Andropogon scoparius* association, and *Andropogon scoparius—Bouteloua* association, earliest adult, May 9, 1928, and latest adult, Aug. 6, 1928. Common at *Amorpha canescens* families.

*Lepidocricus herricki* Pierce

Taken on flower of *Fragaria virginiana*, 2.5 mi. south of Ames, May 12, 1926, one specimen.

*Brachyrhinus ovatus* Linn.

At *Spartina* consocies, 2.5 mi. south of Ames, June 26, 1926, one specimen.

*Aphrastus taeniatus* Gyll.

At *Andropogon furcatus* consocies, 6 mi. northwest of Cedar Falls, July 17, 1928, one specimen.

*Sitona flavescens* Marsh.

At *Andropogon furcatus—Spartina Michauxiana* associes, 2.5 mi. south of Ames, Aug. 7, 1925, and 6 mi. northwest of Ledyard, Aug. 7, 1928. Four specimens.

*Sitona hispidula* Germ.

At *Spartina* consocies. Earliest adult, Aug. 12, 1927; latest adult, Aug. 31, 1927. Not numerous.

*Sitona* (?) *lineellus* Gyll.

At *Stipa spartea—Andropogon scoparius* association, 7.75 mi. northwest of Thompson, Aug. 6, 1928, and 6 mi. northwest of Ledyard, Aug. 7, 1928. Two specimens.

*Sitona tibialis* Hbst.

At *Andropogon furcatus—Spartina Michauxiana* associes, and *Stipa spartea—Andropogon scoparius* association. Earliest adult, May 9, 1926; latest adult, Aug. 6, 1926. Common at *Stipa spartea—Andropogon scoparius* association.

*Hypera punctata* Fab.

At *Andropogon furcatus—Spartina Michauxiana* associes, and *Andropogon furcatus—Sorghastrum nutans* associes. Earliest adult, Aug. 7, 1928; latest adult, Sept. 1, 1928. Probably common at *Spartina* consocies.

*Phytonomus nigrirostris* Fab.

At *Andropogon furcatus—Spartina Michauxiana* associes. Earliest adult, Apr. 16, 1927; latest adult, Aug. 17, 1925. Not numerous.

*Listronotus latiusculus* Boh.

At *Andropogon furcatus—Spartina Michauxiana* associes. Earliest adult, June 5, 1927; latest adult, Aug. 11, 1925. Scarce.

*Hyperodes montanus* Dtz.

At *Spartina* consocies, earliest adult, May 19, 1928, and latest adult, July 11, 1928. Not numerous.

*Hyperodes delumbis* Gyll.

At *Andropogon furcatus* consocies, 5 mi. east of Renwick, May 19, 1928, two specimens.

*Hyperodes sparsus* Say

At *Andropogon furcatus* consocies, 1 mi. southwest of Ames, July 14, 1928, and 2 mi. south of Ledyard, May 9, 1926. Two specimens.

*Hyperodes obscurellus* Dtz.

At *Andropogon furcatus* consocies, 2 mi. south of Ledyard, May 9, 1926, one specimen.

*Notaris bimaculatus* Fab.

At *Phragmites communis*, 5 mi. northwest of Buffalo Center, Aug. 6, 1928, two specimens.

*Pachyphanes discoideus* Lec.

At *Stipa spartea—Andropogon scoparius* association, 7.75 mi. northwest of Thompson, June 30, 1928, one specimen. At *Spartina* consocies, Lake Amana, Aug. 12, 1927, one specimen.

*Desmoris pervisus* Dtz.

Taken on flower bud of *Helianthus grosseserratus*, 2.5 mi. south of Ames, Aug. 26, 1925, one specimen.

*Desmoris constrictus* Say

On *Helianthus grosseserratus*, 1 mi. south of Amana, Aug. 13, 1927, two specimens, and 6 mi. northwest of Ledyard, Aug. 7, 1928, three specimens. At *Andropogon scoparius—Bouteloua curtipendula* association, Oak Grove State Park to Sergeant Bluff, July 25-26, 1928.

*Smicronyx corniculatus* Fahr.

At *Stipa spartea—Andropogon scoparius* association, northeast of Iowa State College grounds, July 11, 1928, one specimen.

*Endalus ovalis* Lec.

At *Andropogon furcatus* consocies, 5 mi. east of Renwick, May 19, 1928, one specimen, and at *Stipa spartea—Andropogon scoparius* association, 7.75 mi. northwest of Thompson, June 30, 1928, one specimen.

*Tanysphyrus lemnae* Fab.

At *Spartina* consocies, 8 mi. southeast of Britt, May 19, 1928, one specimen.

*Bagous* sp.

At *Andropogon furcatus—Spartina Michauxiana* associes, 2.5 mi. south of Ames, June 26, 1926, one specimen, and 5 mi. east of Renwick, May 19, 1928, one specimen.

*Bagous restrictus* Lec.

At *Spartina* consocies, 8 mi. southeast of Britt, one specimen.

*Thysanocnemis helvola* Lec.

At *Andropogon furcatus* consocies, 6 mi. northwest of Le Mars, July 26, 1928, one specimen.

*Tychius tectus* Lec.

At *Andropogon furcatus* consocies, 2 mi. south of Ledyard, May 9, 1926, one specimen, and 6 mi. northwest of Le Mars, July 26, 1928, four specimens.

*Anthonomus* (?) *virgo* Dtz.

At flowers of *Cassia Chamaecrista*, 1 mi. south of Amana, Aug. 25, 1928, two specimens.

*Anthonomus squamosus* Lec.

At *Andropogon scoparius—Bouteloua curtipendula* association, Gitchie-Manito and Oak Grove State Parks, July 24, 25, 1928. Two of the seven specimens were taken at flowers of *Dyssodia papposa*.

*Anthonomus rufipes* Lec.

At *Andropogon furcatus* consocies, 5 mi. east of Renwick, May 19, 1928, two specimens.

*Lixus mucidus* Lec.

All specimens taken from *Polygonum amphibium* socies, a *Polygonum* sp. family, or a community containing a *Polygonum* sp. Earliest adult, June 26, 1926; latest adult, Sept. 16, 1926. Probably common at *Polygonum amphibium* socies, and *Polygonum muhlenbergii* family.

*Lixus fimbriolatus* Boh.

At *Carex* socies, 7.75 mi. northwest of Thompson, June 30, 1928, one specimen.

*Lixus nitidulus* Csy.

At *Carex* socies, 2.5 mi. south of Ames, June 26, 1926, one specimen.

*Lixus terminalis* Lec.

Cut out of stems of *Polygonum pennsylvanicum* in which the larvae had grown and pupated, 2 mi. west of Kelso, July 30, 1928. Numerous. At *Polygonum amphibium* socies, earliest adult, June 26, 1926, and latest adult, Aug. 1, 1928.

*Lixus* sp. 1

At *Spartina* consocies, 2.5 mi. south of Ames, June 26, 1926, one specimen.

*Lixus* sp. 2

At *Andropogon scoparius*, 7.75 mi. northwest of Thompson, Aug. 6, 1928, one specimen. A second specimen came from a pupa found in the lower part of a stem of *Cicuta maculata*, 7.75 mi. northwest of Thompson. The pupa stage was secured Aug. 6, and the adult appeared Aug. 7, 1928.

*Baris striata* Say

Swept from *Astralagus caryocarpis* family, 5 mi. south of Stanhope, June 15, 1928, two specimens, and from *Amorpha canescens*, same locality and date, one specimen. At *Stipa spartea—Andropogon scoparius* association, Ocheyedan Mound, July 23, 1928, and 7.75 mi. northwest of Thompson, June 30, 1928, two specimens.

*Baris transversa* Say

At *Andropogon furcatus—Sorghastrum nutans* associes, 1 mi. south of Amana, July 20, 1928, two specimens.

*Baris deformis* Csy.

At *Andropogon furcatus* consocies. Earliest adult, May 12, 1927; latest adult, May 19, 1928. Common.

*Aulobaris naso* Lec.

At *Andropogon furcatus—Sorghastrum nutans* association, 1.5 mi. east of Muscatine, Sept. 1, 1928, and 1.5 mi. east of Verdi, Aug. 20, 1928. One specimen on each date.

*Pseudobaris nigrina* Say

At *Andropogon furcatus* consocies, 2 mi. south of Ledyard, May 9, 1928, one specimen.

*Centrinus penicellus* Hbst.

At *Polygonum amphibium* socies, 10 mi. southwest of Kelso, July 30, 1928, one specimen, and at *Andropogon scoparius—Bouteloua curtipendula* association, Council Bluffs, July 31, 1928, one specimen.

*Odontocorynus salebrosus* Csy.

On flowers of *Erigeron ramosus,* and *Rudbeckia hirta,* chiefly, at *Andropogon furcatus* consocies, and *Andropogon furcatus—Sorghastrum nutans* associes. Earliest adult, June 23, 1928; latest adult, July 8, 1928. Common.

*Anacentrus deplanatus* Csy.

At *Spartina* consocies, 8 mi. southeast of Britt, May 19, 1928, one specimen.

*Cylindrocopturus operculatus* Say

Swept from *Helianthus Maximiliani,* 10 mi. southwest of Kelso, July 30, 1928, one specimen.

*Cylindrocopturus sparsus* Csy.

At *Elymus virginicus,* 1 mi. south of Amana, Aug. 13, 1927, one specimen.

*Ceutorhynchus rapae* Gyll.

Swept from flowers of *Cicuta maculata,* 2.5 mi. south of Ames, July 10, 1928, one specimen.

*Ceutorhynchus sulcipennis* Lec.

At *Polygonum amphibium* socies, chiefly. Earliest adult, May 12, 1926; latest adult, Aug. 14, 1926. Numerous.

*Ceutorhynchus cyanipennis* Germ.

At *Andropogon furcatus* consocies, 5 mi. east of Renwick, May 19, 1928, one specimen.

*Ceutorhynchus neglectus* Blatch.

At *Polygonum amphibium* socies, 2.5 mi. south of Ames, Aug. 9, 1926, one specimen.

*Rhinoncus pericarpius* Fab.

At *Polygonum amphibium* socies. Earliest adult, Mar. 25, 1928; latest adult, Aug. 7, 1928. Numerous.

*Rhinoncus pyrrhopus* Boh.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Aug. 17, 1926, and at *Polygonum amphibium* socies, 2 mi. west of Pacific Junction, July 31, 1928. Two specimens.

*Amalus haemorrhous* Hbst.

At *Spartina* consocies, 8 mi. southeast of Britt, May 19, 1928, one specimen. At *Andropogon furcatus* consocies, 5 mi. east of Renwick, May 19, 1928, one specimen.

*Conotrachelus geminatus* Dej.

Swept from *Ambrosia trifida*, 1 mi. south of Amana, Aug. 12, 1927, one specimen.

*Conotrachelus anaglypticus* Say

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, and 7.75 mi. northwest of Thompson, June 30, 1928. Two specimens.

*Sphenophorus striatipennis* Chttn.

At *Carex* socies, 7.75 mi. northwest of Thompson, June 30, 1928, one specimen.

*Sphenophorus parvulus* Gyll.

At *Spartina* consocies, 2.5 mi. south of Ames, May 21, 1927, one specimen. At *Spartina* consocies, Gitchie-Manito State Park, July 24, 1928, two specimens.

## ORDER TRICHOPTERA

The specimen was determined by Dr. Cornelius Betten.

*Leptocerus* sp.

At *Carex* socies, Lake Amana, June 23, 1928, one specimen.

## ORDER LEPIDOPTERA

The species were determined by Dr. W. T. M. Forbes, and Messrs. Carl Heinrich, August Busck and W. Schaus. The arrangement follows Barnes and McDunnough (1917).

*Eurymus eriphyle* Edw.

At *Andropogon furcatus* consocies, July 29, 1925, and Aug. 9, 1926. Two specimens.

*Cercyonis alope olympus* Edw.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Aug. 19, 1925, one specimen. A larva was taken at *Stipa spartea—Andropogon scoparius* association northeast of Iowa State College grounds, July 11, 1928. It fed a little on *Andropogon scoparius* leaves, and pupated July 17. The adult appeared Aug. 13, 1928. Several adults were seen at all communities higher than *Spartina* consocies nearly every time they were visited in July and August of each year.

*Chrysophanus hypophlaeas* Bdv.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, June 1, 1926, one specimen.

*Lycaena camyntas* Godt.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 20, 1925, one specimen.

*Celerio lineata* Fabr.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Sept. 13, 2926, one specimen.

*Hyphantria cunea* Dru.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Aug. 17, 1926, one specimen.

*Estigmene acraea* Dru.

A larva was taken on *Polygonum amphibium*, 1 mi. south of Amana, Aug. 21, 1928. It fed on *P. amphibium* leaves, and pupated Aug. 25. The adult appeared Sept. 15, 1928. A second larva was taken on *P. amphabium*, 2.5 mi. south of Ames, and the adult appeared Sept. 14, 1928.

*Isia isabella* Sm. and Abb.

A larva of this species was taken at *Andropogon furcatus* consocies, under a board, Mar. 23, 1926.

*Lygranthoecia brevis* Grote

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, July 11, 1928, one specimen.

*Lygranthoecia marginata* Haw.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Aug. 16, 1926, one specimen, and at *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Aug. 17, 1926, one specimen.

*Schinia lynx* Gn.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, June 1, 1926, one specimen.

*Ceramica picta* Harr.

At *Polygonum amphibium* socies, *Carex* socies, and *Spartina* consocies, 2.5 mi. south of Ames, the larvae of this species were numerous, June 26, 1926.

*Cirphis unipuncta* Haw.

Three larvae of this species were taken under debris at *Spartina* consocies, 2.5 mi. north of Ames, May 7, 1928. An adult moth was reared from one of the larvae.

*Cirphis* sp.

One larva was taken at *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Oct. 11, 1926. One larva was taken at *Andropogon furcatus* consocies, 5 mi. northwest of Buffalo Center, Sept. 16, 1928.

*Nephelodes albilinea* Hbn.

At *Stipa spartea—Andropogon furcatus* association, 2 mi. north of Ames, Oct. 11, 1926, seven larvae. At *Andropogon furcatus* consocies, 5 mi. northwest of Buffalo Center, Sept. 16, 1928, the larvae were numerous on the grass.

*Macronoctua onusta* Grt.

Reared from a larva that was a stalk-borer of *Iris versicolor* which occurred 3.5 mi. north of Ledyard. It was brought in July 23, 1928, pupated Sept. 10, and the adult appeared Sept. 20, 1928.

*Luperina stipata* Morr.

Three larvae were found among roots of *Spartina Michauxiana,* 2.5 mi. north of Ames, July 6, 1928. At *Spartina* consocies, 1 mi. south of Gruver, July 8, 1928, one hundred and eighty larvae were taken from six square feet of sod dug to a depth of nine inches.

*Papaipema marginidens* Gn.

Several larvae as stalk-borers of *Cicuta maculata* which occurred 7.75 mi. northwest of Thompson, were found Aug. 6, 1928.

*Papaipema arctivorens* Hamp.

A larva was taken as a stalk-borer of *Cirsium* sp., 3.5 mi. north of Ledyard, July 7, 1928. It pupated, and the adult appeared Aug. 20, 1928.

*Papaipema cataphracta* Grt.

The larva was taken as a stalk-borer of *Cirsium iowense,* 5 mi. south of Stanhope, July 30, 1928. It pupated Aug. 8, and the moth appeared Sept. 9, 1928.

*Papaipema sciata* Bird

Three larvae, stalk-borers of *Veronica virginica,* were taken 1 mi. south of Amana, July 13, 1928. Two specimens taken from *V. virginica,* 2.5 mi. south of Ames, July 15, 1928.

*Papaipema necopina* Grt.

A larva was taken as a stalk-borer of *Helianthus grosseserratus,* 2.5 mi. south of Ames, Aug. 17, 1928. It pupated, and the moth appeared Sept. 10, 1928.

*Papaipema eryngii* Bird

Five larvae were taken as stalk-borers of *Eryngium yuccifolium,* 5 mi. northwest of Buffalo Center, Aug. 6, 1928. Several pupated about Sept. 5, and an adult appeared Sept. 22, 1928.

*Lithacodia bellicula* Hbn.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 29, 1925, and 5 mi. east of Renwick, May 19, 1928. One specimen on each date.

*Tarachidia candefacta* Hbn.

At flowers of *Zizia aurea,* 2.5 mi. south of Ames, May 27, 1926. Several specimens were seen, and one taken.

*Caenurgia crassiuscula* Haw.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Aug. 9, 1926, two specimens. At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Apr. 18, 1927, and July 11, 1928, two specimens.

*Autographa falcifera* Kby.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, May 3, 1926, one specimen.

*Drasteria erechtea* Cram.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, May 27, 1926, two specimens.

*Ptychopoda inductata* Guen.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Aug. 4, 1927, one specimen.

*Eupithecia miserulata* Grote

Two larvae were on leaves of *Zizia aurea,* 1 mi. south of Amana, June 23, 1928. They curled the edges of the leaves, and hid in the folds. The larva pupated in folds of leaves, June 26, and the two adults appeared July 7, 1928.

*Itame flavicaria* Pack.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Aug. 19, 1925, two specimens.

*Hesperia tessellata* Scudd.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Sept. 13, 24, 1926, two specimens.

*Nomophila noctuella* D. & S.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Aug. 4, 1927, one specimen.

*Pyrausta flavidalis* Guen.

At *Stipa spartea—Andropon scoparius* association, 2 mi. north of Ames, July 11, 1928, one specimen.

*Pyrausta futilalis* Led.

Eight larvae were taken at a family of *Apocynum androsaemifolium,* 2.5 mi. south of Ames, July 11, 1928. These larvae with a number of others had spread a web over the upper leaves and stalks of the plants, and were feeding on the leaves. They pupated July 19, 20, 22, and six adults appeared Aug. 8, 10, 11, 1928.

*Pyrausta* sp. near *onythesalis* Wlk.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 11, 1928, one specimen.

*Crambus* sp.

At *Andropogon scoparius,* 7.75 mi. northwest of Thompson, June 30, 1928, numerous. At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Aug. 4, 1927, one specimen taken and several seen. This species was not represented in the national collection, according to W. Schaus, the determiner.

*Crambus elegans* Cl.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Aug. 14, 1927, five specimens.

*Tetralopha dolorosella* B. & B.

Two larvae were taken from *Amorpha canescens,* 2 mi. north of Ames. They pupated, and appeared as adults, Sept. 11, 1926. A third moth was reared from leaves of *Psoralea tenuiflora,* and the adult appeared Sept. 8, 1928. The dark green larvae of this species were common on *Amorpha canescens* and *Psoralea tenuiflora.*

*Meroptera pravella* Grote

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 29, 1925, one specimen.

*Elasmopalpus lignosellus* Feld.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Aug. 4, 1927, one specimen.

*Polites cernes* B. & L.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Sept. 13, 1926, one specimen.

*Aegeria* sp.

At *Stipa spartea—Andropogon scoparius* association, 7.75 mi. northwest of Thompson, Aug. 6, 1928, one specimen.

*Olethreutes hebesana* Wlk.

The work of a stalk-borer was observed on *Pedicularis canadensis,* 2.5 mi. south of Ames, May 12, 1926. It was brought in June 6, and pupated June 8. The adult appeared June 16, 1926.

*Olethreutes coruscana* Clem.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, June 1, 1926, one specimen.

*Sparganothis unifasciana* Clem.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 10, 1925, and July 11, 1928, two specimens.

*Sparganothis sulfureana* Clem.

An adult, which appeared Sept. 10, 1927, was reared from a larva that fed upon leaves of *Aster* spp. The larva was taken on *Aster* sp., 2.5 mi. south of Ames. A second moth reared from a larva which fed in the flower of *Lilium philadelphicum* that occurred 1 mi. south of Amana. The adult appeared Aug. 8, 1928.

*Sparganothis pallorana* Rob.

Reared from larva taken on *Amorpha canescens,* 5 mi. south of Stanhope. It pupated June 2, 1928, and the adult appeared June 13, 1928. A second adult was reared from a larva on *A. canescens* that occurred 1 mi. south of Amana, and appeared Aug. 12, 1928. A third adult, dated Sept.

12, 1928, came from a larva taken on *Solidago canadensis*, 1 mi. east of Verdi.

*Apantesis phalerata* Harris

At *Andropogon furcatus—Sorghastrum nutans* associes, 6 mi. south of Washington, Aug. 24, 1928, one specimen.

## ORDER DIPTERA

The species were determined by Prof. James S. Hine, Messrs. H. W. Allen, Charles T. Greene, G. S. Walley, and Drs. J. M. Aldrich, Charles P. Alexander, C. Howard Curran, C. L. Fluke, David G. Hall, H. C. Huckett, O. A. Johannsen, and Robert Matheson. The arrangement follows Aldrich (1905).

*Limonia liberta* O. S.

At *Andropogon furcatus—Spartina Michauxiana* associes. Earliest adult, May 12, 1927; latest adult, Aug. 9, 1928. Not numerous.

*Limonia longipennis* Sch.

At *Andropogon furcatus—Spartina Michauxiana* associes. Earliest adult, May 12, 1927; latest adult, Aug. 14, 1926. Not numerous.

*Helobia hybrida* Meig.

At all communities except *Bouteloua hirsuta—B. curtipendula* and *Andropogon scoparius—Bouteloua curtipendula* associations. Earliest adult, Mar. 18, 1927; latest adult, Oct. 20, 1928. Numerous at *Spartina* consocies.

*Nephrotoma altissima* O. S.

At *Andropogon furcatus* consocies, 8 mi. southeast of Britt, Aug. 9, 1928, one specimen.

*Nephrotoma ferruginea* Fabr.

At *Andropogon furcatus—Spartina Michauxiana* associes, chiefly. Earliest adult, May 21, 1927; latest adult, Sept. 19, 1928, at *Stipa spartea—Andropogon scoparius* association. Not common.

*Tipula bicornis* Fabr.

At *Andropogon furcatus—Spartina Michauxiana* associes, 2.5 mi. south of Ames, May 30, 1926, June 5, 1927. Two specimens.

*Chironomus barbipes* Staeg.

At *Spartina* consocies, 8 mi. southeast of Britt, May 19, 1928, two specimens.

*Chironomus brachialis* Coq.

At *Spartina* consocies, Lake Amana, June 23, 1928, one specimen.

*Chironomus crassicaudata* Mall.

At *Spartina* consocies and *Carex* socies, chiefly. Earliest adult, May 9, 1926; latest adult, July 23, 1928. Numerous at Lake Amana, June 23, 1928.

*Chironomus decorus* (?) Joh.

At *Andropogon furcatus—Sorghastrum nutans* associes, 3 mi. south of Muscatine, Sept. 1, 1928, one specimen.

*Chironomus lobiferus* Say

At *Spartina* consocies, chiefly. Earliest adult, May 12, 1927; latest adult, July 24, 1928. Numerous at Lake Amana, June 23, 1928.

*Chironomus pseudoviridis* Mall.

At *Andropogon furcatus—Sorghastrum nutans* associes, 3 mi. south of Muscatine, Sept. 1, 1928, one specimen.

*Chironomus tentans* Fab.

At *Andropogon furcatus—Spartina Michauxiana* associes. Earliest adult, May 12, 1927; latest adult, June 23, 1928. Not common.

*Cricotopus trifascatus* Panz.

At *Spartina* consocies, 2.5 mi. south of Ames, May 12-21, 1927, five specimens.

*Cricotopus trifasciatus* var. *tricinctus* Meig.

At *Spartina* consocies, chiefly. Earliest adult, Apr. 16, 1927; latest adult, June 23, 1928. Numerous.

*Cricotopus exilis* Joh.

At *Andropogon furcatus—Spartina Michauxiana* associes, 2.5 mi. south of Ames, May 12, 1927, three specimens.

*Cricotopus sylvestris* Fabr.

At *Spartina* consocies, 2.5 mi. south of Ames, May 20, 1927, one specimen.

*Tanytarsus nigripalpus* Joh.

At *Andropogon furcatus—Spartina Michauxiana* associes. Earliest adult, Apr. 16, 1927; latest adult, June 5, 1927. Numerous 2.5 mi. south of Ames.

*Forcipomyia specularis* Coq.

At *Spartina* consocies, 2.5 mi. south of Ames, Aug. 24, 1928, two specimens, and 5 mi. east of Renwick, Aug. 9, 1928, two specimens. Swept from *Senecio aureus* family, 1 mi. south of Amana, June 23, 1928, one specimen.

*Probezzia* sp. near *opaca* Loew

At *Andropogon furcatus* consocies, 5 mi. east of Renwick, May 19, 1928, two specimens.

*Protenthes bellus* Loew

Swept from *Rosa pratincola* and *Zizia aurea* families, 1 mi. south of Amana, June 23, 1928, two specimens. At *Carex* socies, same locality and date, one specimen.

*Protenthes stellatus* Coq.

At *Spartina* consocies and *Carex* socies, Lake Amana, June 23, 1928, five specimens.

*Tanypus dyari* Coq.

At *Spartina* consocies, 2.5 mi. south of Ames, May 21, 1927, one specimen.

*Procladius scapularis* Loew

At *Andropogon furcatus—Sorghastrum nutans* associes, 3 mi. south of Muscatine, Sept. 1, 1928, one specimen.

*Psorophora ciliata* Fabr.

At *Spartina* consocies, 2.5 mi. south of Ames, May 26, 1926, one specimen.

*Theobaldia inornata* Will.

At *Andropogon furcatus—Spartina Michauxiana* associes, Oct. 9, 1926, Apr. 16, May 21, 1927, three specimens. At *Bouteloua hirsuta—B. curtipendula* association, 5 mi. south of Stanhope, Oct. 20, 1928, one specimen.

*Culex pipiens* (?) Linn.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 22, 1925, one specimen.

*Culex tarsalis* Coq.

At *Spartina* consocies, 2.5 mi. south of Ames, June 5, 1927, one specimen.

*Aedes fitchii* F. & Y.

At *Andropogon furcatus* consocies, 5 mi. northwest of Buffalo Center, Sept. 16, 1928, one specimen.

*Aedes flavescens* Muller

At *Carex* socies, 7.75 mi. northwest of Thompson, June 30, 1928, one specimen.

*Aedes* (?) *intrudens* Dyar

At *Spartina* consocies, 2.5 mi. south of Ames, July 11, 1928, one specimen.

*Aedes nigromaculis* Ludlow

At *Spartina* consocies, .5 mi. south of Missouri Valley, Aug. 1, 1928, one specimen.

*Aedes sylvestris* Theob.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 22, 31, 1925, three specimens.

*Aedes triseriatus* Say

At *Andropogon furcatus—Sorghastrum nutans* associes, 1 mi. south of Amana, July 20, 1928, two specimens.

*Aedes vexans* Meig.

At *Stipa spartea—Andropogon scoparius* association, and *Andropogon furcatus—Spartina Michauxiana* associes. Earliest adult, June 5, 1927; latest adult, Sept. 15, 1928. Numerous at lights, *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Aug. 3, 1926. The most common and numerous mosquito.

*Eugnoriste occidentalis* Coq.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, June 19, 1926, one specimen.

*Bibio abbreviatus* Loew

At *Andropogon furcatus—Spartina Michauxiana* associes. Earliest adult, May 7, 1926; latest adult, May 18, 1928. Numerous at *Andropogon furcatus* consocies, 4 mi. northwest of Thompson, May 18, 1928.

*Bibio longipes* Loew

Swept from *Solidago canadensis*, 7.75 mi. northwest of Thompson, Sept. 15, 1928, two specimens. At *Stipa spartea—Andropogon scoparius* association, 5 mi. south of Stanhope, Oct. 20, 1928, one specimen.

*Odontomyia pilimanus* Loew

At *Andropogon scoparius—Bouteloua curtipendula* association, Oak Grove State Park, July 25, 1928, two specimens.

*Odontomyia virgo* Wied.

At *Andropogon furcatus* consocies, 6 mi. northwest of Le Mars, July 26, 1928, three specimens.

*Nemotelus carbonarius* Loew

At *Spartina* consocies, 2.5 mi. south of Ames ,May 20, 1927, one specimen. Swept from *Solidago* sp., 1.5 mi. northeast of Ocheyedan, July 23, 1928, one specimen.

*Nemotelus unicolor* Loew

At *Spartina* consocies, 2.5 mi. south of Ames, May 20, 1927, two specimens.

*Chrysops sequax* Will.

At *Spartina* consocies, 3.5 mi. north of Ledyard, Aug. 7, 1928, one specimen.

*Tabanus costalis* Wied.

Swept from *Spartina* consocies, chiefly. Earliest adult, July 9, 1928; latest adult, Aug. 13, 1927. Common.

*Tabanus susurrus* Marten

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, May 31, 1926, one specimen.

*Chrysopila foeda* Loew

At *Spartina* consocies, 2.5 mi. south of Amana, May 21, 1927, two specimens.

*Chrysopila modesta* Loew

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 20, 1925, one specimen.

*Chrysopila proxima* Walk.

At *Carex* socies, Lake Amana, June 23, 1928, one specimen. At *Stipa spartea—Andropogon scoparius* association, earliest adult, June 30, 1928, and latest adult, Aug. 9, 1928. Not numerous.

*Chrysopila quadrata* Say

At *Stipa spartea—Andropogon scoparius* association, 7.75 mi. northwest of Thompson, June 30, 1928, one specimen.

*Exoprosopa fasciata* Macq.

Nearly all specimens were taken at flowers of *Liatris pycnostachya.* Earliest adult, Aug. 5; latest adult, Aug. 18, 1928. Common at *Andropogon furcatus* consocies.

*Anthrax* sp.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 20, 1926, one specimen.

*Villa fulvohirta* Wied.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 9, 1926, July 10, 1928, three specimens.

*Villa lateralis* Say

At flower of *Steironema lanceolata,* 2.5 mi. south of Ames, Aug. 11, 1928, one specimen.

*Systoechus candidulus* Loew

At *Stipa spartea—Andropogon scoparius* association, 5 mi. south of Stanhope, Aug. 5, 1927, three specimens.

*Systoechus vulgaris* Loew

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 20, 1925, one specimen. At flower of *Heliopsis scabra,* same locality, Aug. 26, 1926, one specimen.

*Phthiria punctipennis* Walk.

At *Andropogon scoparius—Bouteloua curtipendula* association, Gitchie-Manito State Park, July 24, 1928, one specimen.

*Phthiria sulphurea* Loew

At *Stipa spartea—Andropogon scoparius* association, Ocheyedan Mound, July 23, 1928, one specimen, and 2 mi. north of Ames, Aug. 14, 1926, one specimen.

*Sparnopolius fulvus* Wied.

At flowers of *Vernonia* sp. and *Solidago canadensis,* 1.5 mi. east of Muscatine and 1.5 mi. east of Verdi, Sept. 1, 5, 1928. Two specimens.

*Geron senilis* Fabr.

At flower of *Lepachys pinnata,* 2 mi. north of Ames, Aug. 14, 1926, one specimen.

*Psilocephala aldrichii* Coq.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 9, Aug. 9, 1926, two specimens.

*Psilocephala frontalis* Cole

At all communities except *Andropogon furcatus—Sorghastrum nutans* associes. Earliest adult, May 20, 1927; latest adult, Aug. 19, 1927. Probably common at *Andropogon scoparius—Bouteloua curtipendula*, and *Stipa spartea—Andropogon scoparius* associations.

*Psilocephala haemorrhoidalis* Macq.

At *Andropogon scoparius—Bouteloua curtipendula* association, Gitchie-Manito State Park, July 24, 1928, one specimen. At *Spartina* consocies, 2.5 mi. north of Ames, Aug. 5, 1927, and 4 mi. north of Le Mars, July 26, 1928, two specimens. At *Andropogon furcatus* consocies, 6 mi. north of Le Mars, July 26, 1928, one specimen.

*Leptogaster murinus* Loew

At all communities except *Bouteloua hirsuta—B. curtipendula* association. Earliest adult, June 7, 1928; latest adult, Aug. 6, 1928. Common at *Stipa spartea—Andropogon scoparius* association.

*Leptogaster flavipes* Loew

At *Carex* socies, 1 mi. south of Amana, June 2?, 1928, one specimen. At *Andropogon scoparius—Bouteloua curtipendula* association, Gitchie-Manit State Park, July 24, 1928, one specimen.

*Echthodopa pubera* Loew

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, May 25, 1926, two specimens.

*Holcocephala abdominalis* Say

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 10-16, 1925. Common.

*Atomosia puella* Weid.

At *Andropogon scoparius—Bouteloua curtipendula* association, 15 mi. north of Sioux City, July 26, 1928, one specimen.

*Erax aestuans* Linn.

At *Andropogon furcatus—Sorghastrum nutans* associes, 1 mi. south of Amana, June 23, 1928, two specimens. At *Spartina* consocies, 7.75 mi. northwest of Buffalo Center, July 7, 1928, one specimen.

*Promachus vertebratus* Say

At *Andropogon furcatus* consocies, *Andropogon furcatus—Sorghastrum nutans* associes, and *Stipa spartea—Andropogon scoparius* association where *Compositae* are more numerous. Earliest adult, Aug. 4, 1928; latest adult, Sept. 19, 1928. Common.

*Asilus erythrocnemius* Hine

At *Andropogon furcatus* consocies, and *Andropogon scoparius—Bouteloua curtipendula* association, chiefly. Earliest adult, June 1, 1926; latest adult, Aug. 9, 1928. Common at *Andropogon furcatus* consocies.

*Asilus leucopogon* Will.

At *Andropogon scoparius—Bouteloua curtipendula* association, 15 mi. north of Sioux City, July 26, 1928, one specimen.

*Asilus paropus* Walk.

At *Andropogon furcatus* consocies, and *Stipa spartea—Bouteloua curtipendula* association. Earliest adult, July 7, 1928; latest adult, Aug. 6, 1928. Common at *Andropogon furcatus* consocies.

*Asilus snowii* Hine

At *Spartina* consocies, 2.5 mi. south of Ames, June 28, 1928, 2 mi. west of Kelso, July 30, 1928, and 5 mi. northwest of Buffalo Center, July 7, 1928. At *Andropogon scoparius*, 7.75 mi. northwest of Thompson, Aug. 6, 1928. One specimen on each date.

*Psilopodinus sipho* Say

At all communities except *Andropogon furcatus—Sorghastrum nutans* associes, and *Andropogon scoparius—Bouteloua curtipendula* association. Earliest adult, July 16, 1925; latest adult, Aug. 26, 1926. Common at *Spartina* consocies.

*Sciapus caudatus* Weid.

At *Andropogon furcatus* consocies, 3.5 mi. north of Ledyard, Aug. 7, 1928, and 5 mi. east of Renwick, Aug. 9, 1928, two specimens.

*Sciapus flavipes* Ald.

At *Spartina* consocies. Earliest adult, Aug. 1, 1928; latest adult, Aug. 9, 1928. Numerous.

*Chrysotus hirtipes* V. D.

At *Carex* socies, Lake Amana, June 23, 1928, one specimen.

*Chrysotus picticornis* Loew

At *Spartina* consocies, 2.5 mi. south of Ames, May 20, 30, 1927, four specimens.

*Medeterus lobatus* V. D.

At *Stipa spartea—Andropogon scoparius* association, 7.75 mi. northwest of Thompson, June 30, 1928, one specimen. At *Carex* socies, same locality, Aug. 6, 1928, one specimen.

*Medeterus veles* Loew

At *Andropogon scoparius—Bouteloua curtipendula* association, 1 mi. west of Hamburg, July 30, 1928, one specimen.

*Dolichopus bifractus* Loew

At all communities except *Bouteloua hirsuta—B. curtipendula* association. Earliest adult, July 22, 1925; latest adult, Sept. 15, 1927. Common.

*Dolichopus comatus* Loew

At *Andropogon furcatus—Spartina Michauxiana* associes, chiefly. Earliest adult, May 12, 1927; latest adult, Aug. 4, 1927. Common at *Spartina* consocies.

*Dolichopus latipes* Loew

At *Spartina* consocies, and *Carex* socies. Earliest adult, June 30, 1928; latest adult, Aug. 12, 1927. Scarce.

*Dolichopus pachynemus* Loew

At *Spartina* consocies, Lake Amana, June 23, 1928, two specimens.

*Dolichopus ramifer* Loew

At *Spartina* consocies, chiefly. Earliest adult, May 2, 1928; latest adult, July 30, 1928. Common.

*Pelastoneurus vagans* Loew

At *Spartina* consocies, chiefly. Earliest adult, May 12, 1928; latest adult, Aug. 1, 1928. Common.

*Drapetis unipila* Loew

At *Spartina* consocies, 4 mi. northwest of Thompson, May 18, 1928, one specimen.

*Platypalpus holosericeus* Mel.

At *Polygonum amphibium* socies, 6 mi. northwest of Ledyard, Aug. 7, 1928, one specimen.

*Hybos triplex* Walk.

At *Spartina* consocies, and *Carex* socies, Lake Amana, June 23, 1928, two specimens. At *Andropogon scoparius,* 7.75 mi. northwest of Thompson, June 30, 1928, one specimen.

*Empis nuda* Loew

At *Andropogon furcatus—Spartina Michauxiana* associes, 8 mi. southeast of Britt and 7.75 mi. northwest of Thompson, May 18, 1928. Numerous.

*Pipunculus affinis* Cres.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Aug. 26, 1926, one specimen. At *Polygonum amphibium* socies, 10 mi. southwest of Kelso, July 30, 1928, one specimen.

*Pipunculus fasciatus* Loew

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 16, 1925, one specimen.

*Pipizella pulchella* Will.

At flowers of *Cicuta maculata,* 5 mi. northwest of Buffalo Center, July 7, 1928, one specimen.

*Paragus bicolor* Fabr.

At *Spartina* consocies, 2.5 mi. south of Ames, May 12, 1927, and 7.75 mi. northwest of Thompson, Aug. 6, 1928. Two specimens.

*Paragus tibialis* Fall.

At *Andropogon furcatus* consocies, 3.5 mi. north of Ledyard, July 7, 1928, one specimen. At *Stipa spartea—Bouteloua curtipendula* association, 5 mi. south of Stanhope, Aug. 5, 1927, four specimens.

*Platychirus immarginatus* Zett.

At *Andropogon furcatus—Spartina Michauxiana* associes, chiefly. Earliest adult, May 12, 1928; latest adult, Sept. 19, 1928. Common.

*Platychirus quadratus* Say

At all communities except *Bouteloua hirsuta—B. curtipendula* association, and *Andropogon scoparius—Bouteloua curtipendula* association. Earliest adult, May 12, 1927; latest adult, Sept. 19, 1928. Not common.

*Melanostoma mellinum* Linn.

At *Spartina* consocies, 8 mi. southeast of Britt, May 19, 1928, and 6 mi. northwest of Ledyard, Aug. 7, 1928. Two specimens.

*Allograpta obliqua* Say

Nearly all specimens were taken at flowers of *Silphium laciniatum*, 2.5 mi. south of Ames, July 27, 1926, where they were numerous. At *Rosa pratincola* flower, 8 mi. southeast of Britt, July 6, 1928, one specimen.

*Mesogramma marginata* Say

At all communities. Earliest adult, June 5, 1927; latest adult, Sept. 15, 1928. The most common syrphid. Numerous at flowers of *Cicuta maculata, Rosa pratincola,* and *Rudbeckia hirta.*

*Mesogramma polita* Say

At *Andropogon furcatus—Sorghastrum nutans* associes, 3 mi. south of Muscatine, Sept. 1, 1928, four specimens, 1.5 mi. east of Verdi, Aug. 20, Sept. 5, 1927, two specimens.

*Sphaerophoria cylindrica* Say

At all communities except *Bouteloua hirsuta—B. curtipendula* association. Numerous at flowers of *Cicuta maculata* and *Rudbeckia hirta.* Common, but not as numerous as *Mesogramma marginata.*

*Sphaerophoria scripta* Linn.

At flowers of *Cicuta maculata,* 2.5 mi. south of Ames, July 10, 1928. At flower of *Rudbeckia hirta,* 8 mi. southeast of Britt, July 6, 1928. At flowers of *Cicuta maculata,* 5 mi. east of Renwick, July 8, 1928. At *Bouteloua hirsuta—B. curtipendula* association, 5 mi. south of Stanhope, Sept. 19, 1928. One specimen at each locality.

*Neoascia globosa* Walk.

At *Spartina* consocies, 4 mi. northwest of Thompson, May 18, 1928, one specimen.

*Eristalis latifrons* Loew

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Aug. 11, 1925. At flower of *Liatris pycnostachya,* same locality, Aug. 11, 1927, and at flower of *Rudbeckia hirta,* same locality, July 9, 1928. One specimen on each date.

*Helophilus latifrons* Loew

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Aug. 11, 1925, one specimen. At flowers of *Cassia Chamaecrista,* Aug. 12, 1927, one specimen.

*Syritta pipiens* Linn.

At flowers of *Cicuta maculata,* 2.5 mi. south of Ames, Aug. 4, 1928, one specimen.

*Zodion fulvifrons* Say

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 10, 1925, one specimen.

*Zodion obliquefasciatum* Macq.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 2, 1926, four specimens. At flower of *Helianthus* sp., same locality, Aug. 9, 1926, one specimen.

*Oncomyia abbreviata* Loew

At *Andropogon scoparius—Bouteloua curtipendula* association, 1 mi. west of Hamburg State Park, July 30, 1928, two specimens. At *Stipa spartea—Andropogon scoparius* association, Ocheyedan Mound, July 23, 1928, one specimen.

*Phorantha occidentis* Walk.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Aug. 17, 1926, one specimen.

*Schizotachina convecta* Walk.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Aug. 11, 1925, one specimen.

*Celatoria diabroticae* Shim.

At *Bouteloua hirsuta—B. curtipendula* association, 5 mi. south of Stanhope, Sept. 19, 1928, one specimen.

*Polidea areos* Walk.

At *Spartina* consocies, 2.5 mi. south of Ames, Aug. 9, 1926, two specimens. At *Polygonum amphibium* socies, same locality and date, one specimen. At flowers of *Liatris pycnostachya,* same locality, July 30, 1926, one specimen.

*Leucostoma atra* Tns.

At *Andropogon scoparius—Bouteloua curtipendula* association, Gitchie-Manito State Park, July 24, 1928, and Sergeant Bluff, July 26, 1928. At *Stipa spartea—Andropogon scoparius* association, 5 mi. south of Stanhope, Aug. 5, 1927. One specimen on each date.

*Siphophyto floridensis* Tns.

At *Andropogon furcatus* consocies, 3.5 mi. north of Ledyard, July 7, 1928, one specimen. At *Stipa spartea—Andropogon scoparius* association, 5 mi. northwest of Buffalo Center, Aug. 6, 1928, one specimen.

*Phytoadmontia setigera* Coq.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Sept. 26, 1926, one specimen.

*Cylindromyia argentea* Tns.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, June 18, 1926, one specimen.

*Cylindromyia decora* Aldrich

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, June 19, 1926, one specimen, and 3.5 mi. north of Ledyard, July 7, 1928, two specimens. At *Andropogon furcatus—Sorghastrum nutans* associes, 3 mi. north of Muscatine, Sept. 1, 1928, one specimen.

*Voria ruralis* Meig.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, June 25, 1926, one specimen.

*Ernestia ampelus* Walk.

At *Andropogon furcatus* consocies, 5 mi. east of Renwick, May 9, 1928, one specimen.

*Exorista nigripalpis* Tns.

At *Andropogon furcatus—Spartina Michauxiana* associes, 2.5 mi. south of Ames, June 26-July 6, 1926. Most of the specimens were swept from flowers of *Cicuta maculata*. Common at *Spartina* consocies.

*Exorista simulans* Meig.

At *Stipa spartea—Andropogon scoparius* association, 5 mi. northwest of Buffalo Center, July 7, 1928, one specimen. At *Spartina* consocies, 2.5 mi. south of Ames, June 5, 1927, one specimen.

*Phorocera claripennis* Macq.

Swept from flowers of *Cicuta maculata*, 2.5 mi. south of Ames, July 6, 1926, two specimens.

*Doryphorophaga doryphorae* Riley

At *Spartina* consocies, 5 mi. east of Renwick, Aug. 9, 1928, one specimen.

*Zenillea crassiseta* A. & W.

At flower of *Rudbeckia hirta*, 5 mi. east of Renwick, July 7, 1928, one specimen. At flowers of *Cicuta maculata*, same locality and date, July 8, 1928, one specimen.

*Masicera pauciseta* Coq.

At flowers of *Vernonia noveboracensis*, 2.5 mi. south of Ames, July 19, 1928, two specimens.

*Masicera* near *rutila* Meig.

At *Andropogon furcatus* consocies, 3.5 mi. north of Ledyard, July 7, 1928, one specimen.

*Erycia myoidaea* Desv.

Swept from flowers of *Cicuta maculata,* 2.5 mi. south of Ames, Aug. 4, 1928, one specimen. At *Andropogon scoparius,* 7.75 mi. northwest of Thompson, Aug. 6, 1928, one specimen.

*Ceromasia senilis* Meig.

At *Andropogon furcatus* consocies, 3.5 mi. north of Ledyard, July 7, 1928, one specimen.

*Tachinomyia robusta* Town.

At *Spartina* consocies, 5 mi. east of Renwick, May 8, 1926, one specimen.

*Winthemia quadripustulata* Fabr.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Aug. 9, 1926, one specimen. *At Andropogon furcatus—Sorghastrum nutans* associes, 6 mi. south of Washington, Sept. 7, 1927, one specimen. Two specimens were reared as parasites of a salt-marsh caterpillar (*Estigmene acraea* Dru.) taken on *Polygonum amphibium,* 2.5 mi. south of Ames, July 11, 1928. The maggots left the host and pupated July 19, 1928. The adult flies appeared Sept. 21, 1928.

*Metachaeta atra* Coq.

At flower of *Rudbeckia hirta,* 1 mi. south of Amana, June 23, 1928. At *Stipa spartea—Bouteloua curtipendula* association, 7.75 mi. northwest of Thompson, May 18, 1928. One specimen was reared from an armyworm (*Cirphis unipuncta* Haw.). The host was taken on *Andropogon furcatus,* 1.5 mi. east of Verdi, Sept. 5, 1928. The maggot pupated outside of the host, and the adult fly appeared Oct. 8, 1928.

*Brachycoma apicalis* Coq.

At *Andropogon scoparius—Bouteloua curtipendula* association, 1 mi. west of Hamburg State Park, July 30, 1928, one specimen.

*Gonia sequax* Will.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Oct. 1, 1926, one specimen.

*Gonia turgida* Coq.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Apr. 16, 1926, one specimen. At *Stipa spartea—Andropogon scoparius* association, 5 mi. south of Stanhope, Apr. 25, Sept. 19, 1928, three specimens.

*Microphthalma disjuncta* Wied.

At *Spartina* consocies, 4 mi. northwest of Le Mars, July 26, 1928, one specimen.

*Microphthalma michiganensis* Town.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Aug. 3, 1926. The specimen came to lights at night.

*Myiocera cremides* Walk.

At flowers of *Rudbeckia hirta,* 8 mi. southeast of Britt, July 6, 1928, one specimen. At *Andropogon furcatus* consocies, 3.5 mi. north of Ledyard, July 7, 1928, two specimens. At *Stipa spartea—Andropogon scoparius* association, 7.75 mi. northwest of Thompson, June 30, 1928, two specimens.

*Ptilodexia tibialis* Desv.

At flowers of *Rudbeckia hirta,* 8 mi. east of Britt, July 6, 1928, one specimen. At *Andropogon furcatus* consocies and *Stipa spartea—Andropogon scoparius* association, 6 mi. northwest of Ledyard, Aug. 7, 1928, two specimens. At *Stipa spartea—Andropogon scoparius* association, 7.75 mi. northwest of Thompson, June 30, 1928, one specimen.

*Sarcophaga communis* Park.

At *Spartina* consocies, Lake Amana, Aug. 12, 1927, and June 23, 1928, two specimens. At flowers of *Cicuta maculata,* 5 mi. northwest of Buffalo Center, July 7, 1928, one specimen.

*Sarcophaga helicis* Tns.

At flower of *Rudbeckia hirta,* 2 mi. north of Ames, Aug. 25, 1926, one specimen. At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Aug. 4, 1925, one specimen, and 8 mi. southeast of Britt, May 19, 1928, two specimens. At *Andropogon furcatus—Sorghastrum nutans* associes, 6 mi. south of Washington, one specimen. At *Stipa spartea—Andropogon scoparius* association, 5 mi. south of Stanhope, May 9, 1928, one specimen, and 7.75 mi. northwest of Thompson, June 30, 1928, one specimen.

*Sarcophaga hunteri* Hg.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Aug. 21, 1925, Sept. 24, 1926, two specimens. At *Andropogon furcatus* consocies, 5 mi. northwest of Buffalo Center, Sept. 16, 1928, one specimen. At flowers of *Cicuta macuata,* 5 mi. northwest of Buffalo Center, two specimens.

*Sarcophaga latisetosa* Park.

At flowers of *Cicuta maculata,* 5 mi. northwest of Buffalo Center, July 7, 1928, one specimen. At *Stipa spartea—Andropogon scoparius* association, 5 mi. south of Stanhope, Aug. 5, 1928, one specimen. At *Andropogon furcatus* consocies, 4 mi. northwest of Thompson, May 18, 1928, one specimen. At *Andropogon furcatus—Sorghastrum nutans* associes, 1.5 mi. east of Verdi, Aug. 20, 1928, one specimen.

*Sarcophaga pachyprocta* Park.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Aug. 13, 1925, Sept. 24, 1926, three specimens. At *Andropogon furcatus* consocies, 8 mi. southeast of Britt, Aug. 6, 1928, one specimen.

*Sarcophaga pallinervis* Thom.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, July 8, 1925, and 7.75 mi. northwest of Thompson, June 30, 1928;

one specimen at each locality. At flowers of *Solidago* sp., 2 mi. north of Ames, Sept. 24, 1926, three specimens. At *Elymus virginicus,* 1 mi. south of Amana, Aug. 13, 1927, one specimen. At *Andropogon furcatus* consocies, 8 mi. southeast of Britt, July 6, 1928, and 5 mi. east of Renwick, May 8, 1926; one specimen at each locality.

*Sarcophaga quadrisetosa* Coq.

At *Stipa spartea—Andropogon scoparius* association, 5 mi. northwest of Buffalo Center, Aug. 6, 1928, one specimen.

*Sarcophaga sinuata* Mg.

At flowers of *Solidago* spp., 2 miles north of Ames, Sept. 24, 1926, and 6 mi. south of Washington, Aug. 24, 1928; one specimen at each locality. At *Spartina* consocies, 2.5 mi. north of Ames, Aug. 5, 1927, two specimens, and Lake Amana, June 23, 1928, one specimen. At flowers of *Cicuta maculata,* 5 mi. northwest of Buffalo Center, July 7, 1928, one specimen

*Sarcophaga spatulata* Ald.

At *Andropogon furcatus—Spartina Michauxiana* associes, 5 mi. northwest of Buffalo Center, July 7, Sept. 6, 1928, two specimens.

*Opelousia obscura* Tns.

At *Stipa spartea—Andropogon scoparius* association, 7.75 mi. northwest of Thompson, June 30, Aug. 6, 1928, two specimens. At *Andropogon scoparius—Bouteloua curtipendula* association, Gitchie-Manito State Park, July 24, 1928, one specimen. At *Polygonum amphibium* socies, .5 mi. south of Missouri Valley, Aug. 1, 1928, one specimen.

*Lucilia caesar* Linn.

At *Spartina* consocies, 2.5 mi. south of Ames, May 20, 1927, one specimen.

*Morellia micans* Macq.

Swept from flowers of *Cicuta maculata,* 2.5 mi. south of Ames, Aug. 4, 1928, one specimen.

*Musca domestica* Linn.

At *Andropogon scoparius—Bouteloua curtipendula* association, Council Bluffs, July 31, 1928, one specimen.

*Stomoxys calcitrans* Linn.

At *Stipa spartea—Andropogon scoparius* association, 5 mi. south of Stanhope, Aug. 5, 1927, one specimen.

*Phaonia deleta* Stein

At *Spartina* consocies, Lake Amana, June 23, 1928, one female specimen.

*Limnophora narona* Walk.

At *Spartina* consocies, chiefly. Earliest adult, June 5, 1927; latest adult, Aug. 19, 1927. Not numerous.

*Calythea pratincola* Pnz.

At *Spartina* consocies, 7.75 mi. northwest of Thompson, Aug. 6, 1928, one specimen.

*Acroptena ambigua* Fall.

At *Spartina* consocies, Lake Amana, June 23, 1928, one specimen.

*Hydrophoria divisa* Meig.

At *Spartina* consocies, 2.5 mi. south of Ames, May 17, 1927, one specimen.

*Hylemyia antiqua* Meig.

At *Stipa spartea—Andropogon scoparius* association, 7.75 mi. northwest of Thompson, May 18, 1928, one specimen.

*Hylemyia cilicrura* Rond.

At all communities except *Bouteloua hirsuta—B. curtipendula* and *Andropogon scoparius—Bouteloua curtipendula* associations. Earliest adult, May 9, 1928; latest adult, Oct. 20, 1928. Numerous at *Stipa spartea —Andropogon scoparius* association.

*Hylemyia depressa* Stein

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Aug. 4, 1927, one specimen.

*Hylemyia fugax* Meig.

At *Stipa spartea—Andropogon scoparius* association, 7.75 mi. northwest of Thompson, May 18, 1928, one specimen.

*Hylemyia parva* R. D.

At all communities except *Andropogon scoparius—Bouteloua curtipendula* association. Earliest adult, June 23, 1928; latest adult, Aug. 6, 1928. Scarce.

*Hylemyia testacea* Stein

Swept from flowers of *Solidago canadensis,* 1 mi. south of Amana, two specimens, male and female.

*Hylemyia variata* Fall.

At *Spartina* consocies, 1 mi. south of Amana and Lake Amana, June 23, 1928, two specimens. At *Carex* socies, 5 mi. northwest of Buffalo Center, July 7, 1928, one specimen.

*Hylemyia salicola* Huck.

At *Spartina* consocies, 2.5 mi. north of Ames, May 7, 1928, one female specimen.

*Eremomyia apicalis* (?) Stein

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Apr. 18, 25, 1927, four specimens. At *Andropogon furcatus* consocies, 2 mi. south of Ledyard, May 9, 1926, one specimen. At flowers of *Solidago canadensis,* 1 mi. south of Amana, Aug. 25, 1927, one specimen.

*Hammomyia unilineata* Zett.

At *Spartina* consocies, 2.5 mi. north of Ames, May 2, 1928, one specimen.

*Paregle cinerea* Fall.

At *Spartina* consocies, 1 mi. south of Amana, June 23, 1928, one specimen, 5 mi. northwest of Buffalo Center, July 7, 1928, one specimen, and 7.75 mi. northwest of Thompson, Aug. 6, 1928, one specimen. At *Stipa spartea—Andropogus scoparius* association, 7.75 mi. northwest of Thompson, May 18, 1928, one specimen. At *Andropogon furcatus* consocies, 2 mi. south of Ledyard, May 9, 1926, one specimen.

*Paregle cinerella* Fall.

At flower of *Anemone patens* var. *Wolfgangiana,* 2 mi. north of Ames, Apr. 9, 1928, one specimen. At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, June 5, 1927, one specimen. At flowers of *Cicuta maculata,* 5 mi. northwest of Buffalo Center, July 7, 1928, two specimens.

*Pegomyia hyoscyami* Panz.

Swept from *Helianthus occidentale,* 5 mi. south of Stanhope, Aug. 19, 1927, one specimen.

*Pegomyia luteola* Mall.

Swept from *Elymus virginicus,* 1 mi. south of Amana, Aug. 13, 1927, one specimen. At *Spartina* consocies, same locality, June 23, 1928, two specimens.

*Pentacricia aldrichii* Stein

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Aug. 13, 1926, one female specimen.

*Coenosia alticola* (?) Mall.

At *Spartina* consocies, 2.5 mi. north of Ames, May 2, 1928, one specimen.

*Coenosia denticornis* Mall.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 16, 20, 1925, three specimens.

*Coenosia hypopygialis* Stein

At *Andropogon furcatus* consocies, 8 mi. southeast of Britt, Aug. 9, 1928, one specimen. At *Stipa spartea—Andropogon scoparius* association, 7.75 mi. northwest of Thompson, Aug. 6, 1928, one specimen.

*Coenosia lata* Walk.

At all communities except *Bouteloua hirsuta—B. curtipendula* association. Earliest adult, May 2, 1928; latest adult, Sept. 15, 1928. Numerous.

*Schoenomyza dorsalis* Loew

At *Andropogon furcatus—Spartina Michauxiana* associes, chiefly. Earliest adult, Mar. 25, 1928; latest adult, Aug. 9, 1928. Numerous during April and May.

*Schoenomyza litorella* Fall.

At *Spartina* consocies, 2.5 mi. south of Ames, Apr. 22, 1928, one specimen.

*Lispa uliginosa* Fall.

At flowers of *Rudbeckia hirta,* 1 mi. south of Amana, June 23, 1928, one specimen.

*Parallelomma varipes* Walk.

At *Polygonum amphibium* socies, 2.5 mi. south of Ames, July 26, Aug. 2, 1926, two specimens. At *Spartina* consocies, 2.5 mi. north of Ames, Aug. 5, 1927, and Lake Amana, June 23, 1928, two specimens.

*Scatophaga furcata* Say

At *Spartina* consocies, 2.5 mi. south of Ames. Earliest adult, Mar. 25, 1928; latest adult, May 30, 1928. Not numerous.

*Leptocera carinata* Spul.

At *Spartina* consocies, 2.5 mi. south of Ames, June 5, 1927, one specimen.

*Leptocera fontinalis* Fall.

At lights, *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Aug. 3, 1926, numerous. At *Spartina* consocies, 2.5 mi. south of Ames, May 12, June 5, 1927, numerous. At *Anemone canadense* flowers, 1 mi. south of Amana, June 23, 1928, one specimen.

*Leptocera lutosa* Stenh.

At *Spartina* consocies, 2.5 mi. south of Ames, May 12, June 5, 1927, and Mar. 25, 1928. Four specimens.

*Borborus equinus* Fall.

At *Stipa spartea—Bouteloua curtipendula* association, 2 mi. north of Ames, Apr. 25, 1927, one specimen. At *Bouteloua hirsuta—B. curtipendula* association, 5 mi. south of Stanhope, Oct. 20, 1928, one specimen. At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Mar. 18, May 12, 1927, two specimens. At *Spartina* consocies, 2.5 mi. south of Ames, May 20, 1927, one specimen.

*Scatophora carolinensis* Desv.

At *Spartina* consocies, 2.5 mi. south of Ames, Mar. 25, 1928, three specimens.

*Melina nana* Fall.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Aug. 14, Oct. 1, 1926, two specimens. At *Spartina* consocies, 2.5 mi. south of Ames, June 5, 1927, one specimen, and 8 mi. southeast of Britt, May 19, 1928, three specimens.

*Melina obtusa* Fall.

At *Carex* socies 7.75 mi. northwest of Thompson, June 30, 1928, one specimen.

*Tetanocera elata* Fabr.

At *Spartina* consocies, chiefly. Earliest adult, May 12, 1927; latest adult, Sept. 16, 1928. Common.

*Dictya umbrarum* Linn.

At all communities except *Andropogon scoparius—Bouteloua curtipendula,* and *Bouteloua hirsuta—B. curtipendula* associations. Earliest adult, Mar. 25, 1928; latest adult, Sept. 7, 1928. Numerous at *Spartina* consocies.

*Limnia saratogensis* Fitch

At all communities. Earliest adult, June 15, 1928; latest adult, Oct. 20, 1928. Common at all communities except *Bouteloua hirsuta—B. curtipendula* and *Andropogon scoparius—Bouteloua curtipendula* associations.

*Minettia lupulina* Fabr.

Swept from *Senecio aureus,* 1 mi. south of Amana, June 23, 1928, one specimen.

*Camptoprosopella vulgaris* Fitch

At flowers of *Erigeron ramosus,* 2 mi. north of Ames, June 25, 1925, one specimen. At *Stipa spartea—Andropogon scoparius* association, 5 mi. south of Stanhope, June 15, 1928, one specimen.

*Pyrgota undata* Wied.

At *Spartina* consocies, 2.5 mi. south of Ames, June 5, 1926, one specimen.

*Rivellia flavimana* Loew

At *Andropogon furcatus* consocies, *Stipa spartea—Andropogon furcatus* association, and *Andropogon furcatus—Sorghastrum nutans* associes. Earliest adult, June 15, 1928; latest adult, Aug. 9, 1928. Not common.

*Rivellia viridulans* Desv.

At *Andropogon furcatus—Spartina Michauxiana* associes, and *Andropogon furcatus—Sorghastrum nutans* associes, chiefly. Common at *Spartina* consocies. Earliest adult, May 31, 1926; latest adult, Sept. 1, 1928.

*Myrmecomyia fenestrata* Coq.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, June 26, Aug. 14, 1926, three specimens. At *Stipa spartea—Bouteloua curtipendula* association, 2 mi. north of Ames, Aug. 9, 1926, one specimen.

*Tritoxa flexa* Wied.

At *Andropogon furcatus* consocies, 3.5 mi. north of Ledyard, July 7, 1928, one specimen. At *Andropogon scoparius—Bouteloua curtipendula* association, Gitchie-Manito State Park, July 24, 1928, one specimen.

*Tritoxa incurva* Loew

At *Andropogon furcatus* and *Elymus virginicus,* 1 mi. south of Amana, Aug. 13, 1927, three specimens. At *Andropogon furcatus* consocies, 6 mi. northwest of Cedar Falls, July 17, 1928, two specimens.

*Eumetopiella rufipes* Macq.

At *Spartina* consocies, 2.5 mi. north of Ames, Aug. 5, 1927, 1 mi. south of Amana, Aug. 13, 1927, and .5 mi. south of Missouri Valley, Aug. 1, 1928. Three specimens.

*Tephronota narytia* Walk.

Swept from *Andropogon furcatus*, 1.5 mi. east of Verdi, Aug. 20, 1928, two specimens.

*Melieria obscuricornis* Loew

Swept from *Phragmites communis* family, 5 mi. northwest of Buffalo Center, Aug. 6, 1926, seven specimens. At *Spartina* consocies, 2.5 mi. south of Ames, June 26, 1926, three specimens and 4 mi. northwest of Le Mars, July 26, 1928, one specimen.

*Melieria ochricornis* Loew

At *Spartina* consocies, chiefly. Earliest adult, May 2, 1926; latest adult, Aug. 9, 1928. Common.

*Chrysomyza demandata* Fabr.

At *Andropogon scoparius—Bouteloua curtipendula* association, Council Bluffs, July 31, 1928, one specimen.

*Chaetopsis aenea* Wied.

At *Andropogon furcatus—Spartina Michauxiana* associes, and *Andropogon furcatus* consocies, chiefly. Earliest adult, May 12, 1927; latest adult, Aug. 24, 1928. Common at *Spartina* consocies.

*Stenomyia nasoni* Cress.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, June 18, 1926, one specimen.

*Straussia longipennis* Wied.

Swept from *Helianthus grosseserratus*, Lake Amana, June 25, 1928, one specimen.

*Eurosta comma* Wied.

At *Andropogon furcatus* consocies, 5 mi. northwest of Buffalo Center, Sept. 16, 1928, one specimen.

*Ensina humilis* Loew

At all communities except *Bouteloua hirsuta—B. curtipendula* association, and *Andropogon furcatus—Sorghastrum nutans* associes. Earliest adult, May 19, 1928; latest adult, Aug. 6, 1928. Common.

*Tephritis aequalis* Loew

At *Andropogon furcatus—Spartina Michauxiana associes*, and *Andropogon scoparius—Bouteloua curtipendula* association. Earliest adult, July 24, 1928; latest adult, Aug. 7, 1928. Scarce at each community.

*Tephritis finalis* Loew

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Aug. 25, Oct. 1, 1926, three specimens.

*Euaresta festiva* Loew

At *Spartina* consocies, 2.5 mi. north of Ames, Aug. 5, 1927, and 4 mi. north of Le Mars, July 26, 1928. Two specimens.

*Euaresta bella* Loew

At all communities except *Bouteloua hirsuta—B. curtipendula* association. Earliest adult, July 16, 1926; latest adult, Sept. 15, 1928. Common; numerous at *Andropogon furcatus* consocies.

*Urellia solaris* Loew

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 20, 1925, one specimen. At *Stipa spartea—Andropogon scoparius* association, Ocheyedan Mound, July 23, 1928, one specimen.

*Calobata alesia* Walk.

At *Carex* socies, 7.75 mi. northwest of Thompson, June 30, 1928, one specimen. At *Spartina* consocies, Lake Amana, June 23, 1928, one specimen.

*Themira putris* Linn.

At *Stipa spartea—Andropogon scoparius* association, 5 mi. northwest of Buffalo Center, July 7, 1928, one specimen.

*Sepsis violacea* Meig.

At *Andropogon furcatus—Spartina Michauxiana* associes, *Andropogon furcatus—Sorghastrum nutans* associes, and *Stipa spartea—Andropogon scoparius* association. Earliest adult, May 12, 1927; latest adult, Sept. 20, 1928. Common at *Spartina* consocies.

*Saltella scutellaris ruficoxa* Macq.

Swept from flowers of *Solidago Riddellii*, 6 mi. south of Washington, Aug. 24, 1926, one specimen.

*Saltella scutellaris* Fall.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 29, 1925, one specimen. At flowers of *Pycnanthemum* sp., 2 mi. north of Ames, Aug. 14, 1926, one specimen.

*Loxocera fumipennis* Coq.

At *Spartina* consocies, 2.5 mi. south of Ames, May 30, 1927, one specimen.

*Notiphila scalaris* Loew

At *Spartina* consocies, 2.5 mi. south of Ames, June 5, 1927, one specimen.

*Paralimna appendiculata* Loew

Swept from *Carex* socies, Lake Amana, June 23, 1928, one specimen.

*Hydrellia scapularis* Loew

At *Spartina* consocies, 2.5 mi. south of Ames, June 5, 1927, one specimen.

*Philygria debilis* Loew

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Apr. 9, 1928, 3.5 mi. north of Ledyard, Aug. 7, 1928, and 5 mi. south of Stanhope, Apr. 25, 1928; one specimen at each locality. At *Spartina* consocies, 8 mi. southeast of Britt, May 19, 1928, one specimen.

*Lytogaster gravida* Loew

At *Spartina* consocies, 2.5 mi. south of Ames, June 5, 1927, two specimens.

*Scatella stagnalis* Fall.

At *Andropogon furcatus—Spartina Michauxiana* associes, 2.5 mi. south of Ames, Apr. 24-May 12, 1927. Common.

*Meromyza americana* Fitch

At all communities except *Andropogon scoparius—Bouteloua curtipendula* and *Bouteloua hirsuta—B. curtipendula* associations. Earliest adult, May 5, 1926; latest adult, Aug. 9, 1928. Numerous at *Andropogon furcatus* consocies.

*Chlorops certima* Adams

At *Spartina* consocies, cheifly. Earliest adult, May 12, 1927; latest adult, Aug. 6, 1928. Scarce.

*Chlorops glabra* Meig.

At *Spartina* consocies and *Carex* socies. Earliest adult, June 23, 1928; latest adult, Sept. 15, 1928. Scarce.

*Chlorops grata* Loew

At *Carex* socies, 7.75 mi. northwest of Thompson, June 30, 1928, one specimen.

*Chlorops obscuricornis* Loew

At *Andropogon furcatus—Spartina Michauxiana* associes, *Andropogon furcatus—Sorghastrum nutans* associes, and *Stipa spartea—Andropogon scoparius* association. Earliest adult, May 9, 1926; latest adult, Sept. 15, 1928. Not common at any community.

*Epichlorops puncticollis* Zh.

At *Andropogon furcatus* consocies, 2 mi. south of Ledyard, May 9, 1926, one specimen. At *Spartina* consocies, 2.5 mi. south of Ames, June 26, 1926, one specimen.

*Diplotoxa microcera* Loew

At *Spartina* consocies, 2.5 mi. south of Ames, May 12, 1927, one specimen.

*Diplotoxa versicolor* Loew

At *Stipa spartea—Andropogon* association, chiefly. Earliest adult, May 19, 1928, latest adult, Aug. 7, 1928. Common.

*Ectecephala similis* Becker

At *Stipa spartea—Andropogon scoparius* association, chiefly. Earliest adult, June 30, 1928, latest adult, Aug. 7, 1928. Common.

*Crassiseta decipiens* Loew

At *Polygonum amphibium* socies, .5 mi. south of Missouri Valley, Aug. 1, 1928, one specimen.

*Crassiseta nigriceps* Loew

At *Spartina* consocies, Lake Amana, June 23, 1928, one specimen.

*Hippelates stramineus* Loew

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Aug. 13, 1926, one specimen.

*Madiza cinerea* Loew

Swept from *Senecio aureus* family, 1 mi. south of Amana, June 23, 1928, one specimen. At *Stipa spartea—Andropogon scoparius* association, 7.75 mi. northwest of Thompson, Sept. 15, 1928, one specimen.

*Oscinella coxendix* Fitch

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, June 19, 1926, and 5 mi. northwest of Buffalo Center, July 7, 1928, three specimens. At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 22, 1925, one specimen.

*Oscinella criddlei* Ald.

At *Spartina* consocies, 1 mi. south of Amana, June 23, 1928, three specimens.

*Oscinella dissidens* Tuck.

At *Spartina* consocies, 4 mi. northwest of Le Mars, July 26, 1928, one specimen.

*Oscinella dorsata* Loew

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Aug. 18, 1926, four specimens; 5 mi. south of Stanhope, June 15, 1928, one specimen, and 7.75 mi. northwest of Thompson, May 18, 1928, one specimen. At *Spartina* consocies, Lake Amana, June 23, 1928, one specimen.

*Oscinella frit* Linn.

At flower of *Fragaria virginiana,* 2.5 mi. south of Ames, June 26, 1926, one specimen.

*Oscinella salina* Curran

At *Spartina* consocies. Earliest adult, May 18, 1928; latest adult, June 5, 1927. Not common.

*Anthomyza tenuis* Loew

At *Stipa spartea—Bouteloua curtipendula* association, 2 mi. north of Ames, June 25, 1925, one specimen.

*Anthomyza variegata* Loew

At *Spartina* consocies, Lake Amana, June 23, 1928, one specimen.

*Napomyza lateralis* Fall.

Reared from flowers of *Pedicularis canadensis*. Pupated May 17, 1926, and adults appeared May 25, 1926. Two specimens.

*Agromyza coquilletti* Mall.

At *Andropogon furcatus* consocies, Apr. 24, 1927, one specimen.

*Agromyza laterella* Zett.

At *Spartina* consocies, 4 mi. northwest of Thompson, May 18, 1928, one specimen.

*Agromyza platyptera* Thoms.

At *Spartina* consocies, Lake Amana, June 23, 1928, one specimen. At *Andropogon furcatus* consocies, 5 mi. east of Renwick, Aug. 9, 1928, one specimen. At *Stipa spartea—Andropogon scoparius* association, 5 mi. south of Stanhope, May 9, 1928, one specimen.

*Agromyza angulata* Loew

At *Spartina* consocies, Lake Amana, June 23, 1928, one specimen, and 1 mi. south of Amana, June 23, 1928, one specimen.

*Agromyza tilliae* Caud.

Ovipositing in flower bud of *Lepachys pinnata*, 2.5 mi. south of Ames, July 10, 1928, one specimen. At *Andropogon furcatus* consocies, same locality, July 10, Aug. 4, 1928, two specimens.

*Cerodontha dorsalis* Loew

At *Andropogon furcatus* consocies, 8 mi. southeast of Britt, Aug. 9, 1928, one specimen. At *Andropogon scoparius—Bouteloua curtipendula* association, Council Bluffs, July 31, 1928, one specimen.

*Meoneura vagans* Fall.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Aug. 18, 1926, one specimen.

*Desmometopa tarsalis* Loew

At *Stipa spartea—Andropogon scoparius* association, 5 mi. south of Stanhope, Aug. 5, 1927, one specimen.

*Euchlorops vittata* Mall.

At *Stipa spartea—Andropogon scoparius* association, Sept. 17, Oct. 9, 1926, two specimens, 2 mi. north of Ames.

*Milichiella lacteipennis* Loew

At *Stipa spartea—Andropogon scoparius* association, 5 mi. northwest of Buffalo Center, July 7, 1928, one specimen.

*Pholeomyia indecora* Loew

At *Stipa spartea—Andropogon scoparius* association. Earliest adult, June 29, 1925; latest adult, Aug. 13, 1925. Common.

*Pseudodinia polita* Mall.

At *Spartina* consocies, 1 mi. south of Amana, Aug. 13, 1927, one specimen. At *Andropogon scoparius—Bouteloua curtipendula* association, 15 mi. north of Sioux City, July 26, 1926, one specimen.

*Mallochiella latipes* Meig.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Apr. 22, 1928, one specimen.

*Leucopis bella* Loew

At *Andropogon scoparius—Bouteloua curtipendula* association, Sergeant Bluff, July 26, 1928, one specimen.

*Leucopis griseola* Fall.

At lights, *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Aug. 3, 1926, one specimen.

*Chamaemyia elegans* Panz.

At *Carex* socies, 7.75 mi. northwest of Thompson, June 30, 1928, one specimen. At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, July 21, 1925, one specimen.

*Chamaemyia polystigma* Meig.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Aug. 25, Sept. 17, 1926, three specimens.

ORDER HYMENOPTERA

The species were determined by Miss Grace Sandhouse, Messrs. S. A. Rohwer, R. A. Cushman, A. B. Gahan, L. H. Weld, W. M. Mann, and Drs. Herbert H. Ross, Theodore H. Frison, and M. R. Smith. The arrangement follows Britton (1916).

*Empria capillata* Mac G.

At *Andropogon furcatus* consocies, and *Stipa spartea—Andropogon scoparius* association. Earliest adult, Apr. 16, 1927; latest adult, Apr. 30, 1926. Five specimens.

*Empria contorta* Mac G.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Apr. 20, 1926, one specimen. At flower of *Fragaria virginiana,* 2.5 mi. south of Ames, May 5, 1926, one female specimen.

*Dolerus collaris* Say

At *Stipa spartea—Andropogon scoparius* association and *Andropogon furcatus* consocies. Earliest adult, Apr. 21, 1926; latest adult, May 12, 1927. Five specimens.

*Dolerus similis* Nort.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, May 21, 1926, one specimen.

*Pristiphora bivittata* Nort.

At *Spartina* consocies, 1 mi. south of Amana, Aug. 13, 1927, one specimen.

*Pachynematus extensicornis* Nort.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, May 3, 1926, one specimen. At *Andropogon furcatus* consocies, 5 mi. east of Renwick, May 19, 1928, one specimen.

*Pachynematus affinis* Marl.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, May 5, 1926, one specimen, and 2 mi. south of Ledyard, May 9, 1926, one specimen.

*Pachynematus auratus* Marl.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, May 21, 1926, three specimens. At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, May 19, 21, 1926, five specimens.

*Anoplolyda cavifrons* Cr.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, June 5, 1926, one specimen.

*Paracharactus rudis* Nort.

At *Stipa spartea—Andropogon scoparius* association, 7.75 mi. northwest of Thompson, May 19, 1928, one specimen.

*Sterictiphora lineata* Roh.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Aug. 17, 1926, one specimen.

*Cephus cinctus* Nort.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, June 23, 1926, one specimen.

*Apanteles bedelliae* Vier.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 10, 1925, one specimen.

*Apanteles crassicornis* Prov.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Aug. 11, 1925, two specimens.

*Apanteles ensiger* Say

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 22, 29, 1925, two specimens.

*Apanteles harti* Cush.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Aug. 7, 1926, one specimen.

*Apanteles plathypenae* Mues.

At *Spartina* consocies, 2.5 mi. south of Ames, May 12, 1926, one specimen.

*Apanteles trachynotus* Vier.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, June 23, 1926, one specimen.

*Microgaster auripes* Prov.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Aug. 25, 1926, one specimen. At *Andropogon furcatus* consocies, May 19, 1926, one specimen.

*Microgaster pantographae* Mues.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, June 19, 1926, one specimen.

*Microplitis brassicae* Mues.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, May 9, 1926, one specimen. At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, May 5, 1926, one specimen.

*Microbracon mellitor* Say

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 22, 1925, May 5, 21, 1926. Four specimens.

*Perilitus eleodis* Vier.

At *Polygonum amphibium* socies, 2.5 mi. south of Ames, June 26, Aug. 2, 1926, two specimens.

*Orgilus detectiformis* Vier.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, June 19, Sept. 17, 1926, two specimens.

*Bassus simillimus* Cress.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 29, 1925, one specimen.

*Bracon nigrosternum* Morr.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 22, 1925. At *Stipa spartea—Andropogon scoparius* association, 2.5 mi. south of Ames, Aug. 4, 1926, one specimen.

*Ascogaster provancheri* D. T.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Aug. 13, 16, 1926, two specimens.

*Ascogaster carpocapsae* Vier.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, June 19, 1926, one specimen.

*Ascogaster erythrethorax* Vier.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Aug. 18, 1926, one specimen.

*Polystenidea parksi* Vier.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Aug. 18, 1926, one specimen.

*Viereckiana bellulus* D. T.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, May 21, 1926, one specimen.

*Paniscus geminatus* Say

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, May 17, 1926, one specimen.

*Paniscus ocellatus* Vier.

At *Andropogon furcatus—Spartina Michauxiana* associes, and *Stipa spartea—Andropogon scoparius* association. Earliest adult, May 21, 1926; latest adult, Aug. 9, 1926. Five specimens.

*Schizoprymnus phillipsi* Vier.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 16, 20, 1925, two specimens.

*Anomalon ejuncidum* Say

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Aug. 7, 1926, one specimen.

*Habronyx apicalis* Cress.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Sept. 24, 1926, one specimen.

*Paranomalon semirufum* Nort.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, May 2, 1926, one specimen.

*Paranomalon propinquum* Cress.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Apr. 12, 1926, one specimen. At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, May 31, 1926, one specimen.

*Ophion abnormis* Felt

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, May 12, 1926, one specimen. At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, May 19, 1926, one specimen.

*Ophion bifoveolatum* Brulle

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, May 17, 1926, one specimen.

*Ophion idoneum* Vier.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Apr. 19, 1926, one specimen.

*Tryphon seminiger* Cress.

At *Spartina* consocies and *Carex* socies, 2.5 mi. south of Ames, June 6, 26, 1926. Three specimens.

*Trematopygus semirufus* Cress.

At *Spartina* consocies, 2.5 mi. south of Ames, Apr. 26, 1926, one specimen.

*Lissonota rubrica* Cress.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 31, 1925, one specimen.

*Arenetra nigrita* Cress.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Apr. 12, 1926, one specimen.

*Ephialtes tenuicornis* Cress.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 9, 1926, one specimen.

*Mesostenus americanus* Cress.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Aug. 12, 1925, one specimen.

*Vipio texanus* Cress.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 22, Aug. 4, 1925, two specimens.

*Trychosis rufoannulatus* Prov.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Aug. 12, 1925, one specimen.

*Hoplocryptus incertulus* Cush.

At *Spartina* consocies, 2.5 mi. south of Ames, May 12, 1926, one specimen.

*Phaeogenes helvolus* Cress.

At *Spartina* consocies, 2.5 mi. south of Ames, June 26, 1926, one specimen.

*Amblyteles suturalis* Say

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, May 7, 1926, one specimen.

*Amblyteles volens* Cress.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Aug. 19, 1925, one specimen. At lights, *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Aug. 3, 1926, one specimen.

*Rhodites utahensis* Bass.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, May 21, 1926, one specimen.

*Antistrophus silphii* G. U.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 10, 1925, one specimen.

*Euplectrus comstocki* How.

Reared from two *Geometridae* larvae which were brought from *Stipa spartea—Andropogon scoparius* association, June 4, 1926. The parasites left the host, June 7, and pupated within light, netlike webs. The adults appeared June 11, 1926. Sixteen specimens were obtained.

*Perilampus chrysopae* Cwfd.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Aug. 25, 1926, one specimen.

*Perilampus fulvicornis* Ashm.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 22, 1925, one specimen.

*Perilampus hyalinus* Say

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, June 24, 28, 1926, two specimens. At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, June 26, 1928, one specimen.

*Pseudometagea schwarzi* Ashm.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 22, 1925, one specimen.

*Haltichella xanticles* Walk.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Oct. 1, 1926, three specimens.

*Spilochalcis albifrons* Walsh.

At *Andropogon furcatus* consocies, July 22, 1925, one specimen.

*Macroteleia macrogaster* Ashm.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Aug. 14, 1926, one specimen.

*Scelio opacus* Prov.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Aug. 25, 1925, one specimen.

*Hebropelte fuscipennis* Ashm.

At *Polygonum amphibium* socies, 2.5 mi. south of Ames, Aug. 2, 1926, one specimen.

*Pelecinus polyturator* Dru.

At *Stipa spartea—Andropogon scoparius* association, *Andropogon furcatus* consocies, and *Andropogon furcatus—Sorghastrum nutans* associes. Earliest adult, Aug. 7, 1928; latest adult, Aug. 25, 1928. Six specimens.

*Ponera coarctata* subsp. *pennsylvanica* Buck.

At *Stipa spartea—Andropogon scoparius* association, 5 mi. south of Stanhope, Apr. 25, 1928, four specimens.

*Crematogaster lineolata* Say

Attending aphids on *Silphium laciniatum,* 2.5 mi. south of Ames, Aug. 25, 1925. At *Andropogon furcatus* consocies, same locality, May 31, 1926. Seven specimens, in total.

*Crematogaster lineolata* var. *cerasi* Fitch

At *Spartina* consocies, Gitchie-Manito State Park, July 24, 1926. At *Andropogon scoparius—Bouteloua curtipendula* association, 1 mi. west of

Hamburg State Park, July 30, 1926, two specimens. At *Andropogon furcatus—Sorghastrum nutans* associes, 1.5 mi. east of Verdi, Aug. 20, 1928, two specimens.

*Stenamma brevicorne* Emery subsp. or var.

At *Spartina* consocies, 2.5 mi. south of Ames, May 12, 1927, one specimen.

*Aphaenogaster fulva aquia* Buck.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Aug. 9, 1926, two specimens taken on the ground, and Apr. 18, 1926, two specimens taken by sweeping.

*Myrmica scabrinodis* Nyl. subsp. or var.

At *Spartina* consocies, and *Andropogon furcatus* consocies, chiefly. Earliest adult, May 2, 1928; latest adult, Sept. 15, 1928. Common.

*Myrmica brevinodis* Emery

On *Helianthus* sp., 2 mi. north of Ames, Aug. 4, 1926, one specimen.

*Myrmica scabrinodis* var. *sabuleti* Mein.

At *Andropogon furcatus* consocies, and *Stipa spartea—Andropogon scoparius* association. Earliest adult, June 30, 1928; latest adult, Aug. 5, 1927. Common.

*Myrmica scabrinodis schencki* var. *emeryana* Forel.

At *Spartina* consocies, 10 mi. southwest of Kelso, July 30, 1928, one specimen.

*Leptothorax curvispinosus* subsp. *ambiguus* Emery

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Apr. 16, 24, 1927, two specimens.

*Leptothorax tricarinatus* Emery

At *Andropogon scoparius—Bouteloua curtipendula* association, 1 mi. west of Hamburg State Park, July 30, 1928, one specimen.

*Dorymyrmex pyramicus* Rog.

At *Andropogon scoparius—Bouteloua curtipendula* association, and *Bouteloua hirsuta—B. curtipendula* association. Earliest adult, July 30, 1928; latest adult, Oct. 20, 1928. Common.

*Iridomyrmex pruinosus* Rog.

At *Andropogon scoparius—Bouteloua curtipendula* association, Council Bluffs, July 31, 1928, one specimen.

*Tapinoma sessile* Say

At *Stipa spartea—Andropogon scoparius* association, and *Andropogon furcatus—Spartina Michauxiana* associes. Earliest adult, Apr. 16, 1927; latest adult, Sept. 15, 1928. Common at *Andropogon furcatus* consocies, and *Spartina* consocies.

*Prenolepis parvula* Mayr.

At *Stipa spartea—Andropogon scoparius* association. Earliest adult, Aug. 5, 1927; latest adult, Sept. 15, 1928. Common.

*Lasius niger* var. *americanus* Emery

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Apr. 26, Aug. 14, 1926, two specimens.

*Lasius niger* var. near *americanus* Emery

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 22, 1925, one specimen.

*Lasius niger* var. *neoniger* Emery

At *Andropogon furcatus—Spartina Michauxiana* associes, *Andropogon furcatus—Sorghastrum nutans* associes, and *Stipa spartea—Andropogon scoparius* association. Earliest adult, May 19, 1928; latest adult, Sept. 15, 1928. Common at *Stipa spartea—Andropogon scoparius* association and *Andropogon furcatus—Sorghastrum nutans* associes.

*Lasius niger alienus* var. *americanus* Emery

At *Stipa spartea—Andropogon scoparius* association, 5 mi. south of Stanhope, May 9, 1928, and 1.5 mi. northeast of Ocheyedan, July 23, 1928. Three specimens.

*Lasius brevicornis* Emery

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Mar. 25. 1928, three specimens.

*Lasius latipes* Walsh

At *Stipa spartea—Andropogon scoparius* association, 5 mi. south of Stanhope, April 25, 1926, common under stones.

*Formica cinerea* var. *neocinerea* Whlr.

At *Andropogon furcatus—Spartina Michauxiana* associes, and *Andropogon furcatus—Sorghastrum nutans* associes. Earliest adult, Apr. 25, 1928; latest adult, Sept. 7, 1928. Common at *Spartina* consocies.

*Formica truncicola integroides* Emery

At *Stipa spartea—Andropogon scoparius* association, chiefly. Earliest adult, June 4, 1926; latest adult, Oct. 9, 1926. Attending aphids (*Aphis* sp.) on *Cirsium iowense,* 2 mi. north of Ames, Aug. 13, 1926, and *Aphis monardae* on *Monarda mollis,* same locality and date. Common.

*Formica pallide—fulva* subsp. *nitidivendris* Emery

At *Stipa spartea—Andropogon scoparius* association, chiefly, 6 mi. northwest of Ledyard, Aug. 7, 1928, and 7 mi. northwest of Thompson, Aug. 6, 1928, three specimens. At *Andropogon furcatus—Sorghastrum nutans* associes, 1.5 mi. southeast of Muscatine, Sept. 1, 1928, one specimen.

*Formica pallide—fulva schaufussi* Mayr.

On *Silphium laciniatum,* 2.5 mi. south of Ames, July 27, 1926, five specimens. On *Cirsium iowense,* same locality, Aug. 9, 1926, two specimens. Common at *Andropogon furcatus* consocies.

*Formica pallide—fulva schaufussi* var. near *incerta* Emery

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, May 25, 31, 1926, two specimens.

*Formica pallide—fulva* var. *incerta* Emery

At *Andropogon furcatus—Spartina Michauxiana* associes, and *Andropogon furactus—Sorghastrum nutans* associes, chiefly. Earliest adult, May 12, 1927; latest adult, Sept. 16, 1928. Common at *Andropogon furcatus* consocies.

*Formica pallide—fulva* Latr. var.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, May 2, 1926, one specimen.

*Formica neogagates* Emery var.

At *Bouteloua hirsuta—B. curtipendula* association, Ocheyedan Mound, July 23, 1928, one specimen. At *Stipa spartea—Andropogon scoparius* association, 5 mi. northwest of Buffalo Center, Aug. 6, 1928, one specimen, 5 mi. south of Stanhope, one specimen, 7 mi. northwest of Thompson, May 18, June 30, Sept. 15, 1928, three specimens, and 1.5 mi. northeast of Ocheyedan, July 23, 1928, one specimen. At *Andropogon scoparius—Bouteloua curtipendula* association, Oak Grove State Park, July 25, 1928, one specimen.

*Formica neogagates lasioides* var. *vetula* Whlr.

At *Stipa spartea—Andropogon scoparius* association, and *Andropogon scoparius—Bouteloua curtipendula* association, chiefly. Earliest adult, May 18, 1928; latest adult, Aug. 7, 1928. Common at *Stipa spartea—Andropon scoparius* association.

*Formica neogagates* var. *vinculans* Whlr.

At *Stipa spartea—Andropogon scoparius* association, chiefly. Earliest adult, May 18, 1928; latest adult, Sept. 19, 1928. Common.

*Formica fusca* var. *argentea* Whlr.

At *Stipa spartea—Andropogon scoparius* association, chiefly. Earliest adult, July 23, 1928; latest adult, Sept. 19, 1928. Common.

*Formica fusca* var. *subsericea* Say

At *Spartina* consocies, chiefly. Earliest adult, May 12, 1926; latest adult, Sept. 15, 1928. Common.

*Formica rufa obscuripe* var. *melanotica* Emery

At *Stipa spartea—Andropogon scoparius* and *Andropogon scoparius—Bouteloua curtipendula* associations, and *Andropogon furcatus* consocies. Earliest adult, Apr. 12, 1926; latest adult, Sept. 19, 1928. Numerous at *Stipa spartea—Andropogon scoparius,* and *Andropogon scoparius—Bouteloua curtipendula* associations.

*Elis atriventris* Gahan

At flowers of *Eryngium yuccifolium,* 2 mi. north of Ames, July 30, 1926, one specimen.

*Elis quinquecincta* Fabr.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 31, 1926, one specimen. At *Elymus virginicus*, 1 mi. south of Amana, Aug. 13, 1927, one specimen. At *Spartina* consocies, 10 mi. southwest of Kelso, July 30, 1928, one specimen. At *Solidago Riddellii*, blooming, 6 mi. south of Washington, Aug. 24, 1928, one specimen.

*Tiphia illinoiensis* Robt.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, July 10, 1925, one specimen.

*Myrmosa unicolor* Say

At *Stipa spartea—Andropogon scoparius* association, 5 mi. south of Stanhope, Aug. 19, 1927, one specimen.

*Pseudomethoca canadensis* Blake

At *Stipa spartea—Andropogon scoparius* association, Ocheyedan Mound, July 23, 1928, one specimen. At *Andropogon scoparius—Bouteloua curtipendula* association, 1 mi. north of Reels City, Aug. 1, 1928, one specimen.

*Pseudomethoca* sp. near *geryon* Fox

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Aug. 7, 1926, one specimen.

*Pseudomethoca sanbornii* Blake

At *Bouteloua hirsuta—B. curtipendula* association, 2 mi. north of Ames, July 14, 1926, one specimen.

*Dasymutilla interrupta* Banks

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, May 31, 1926, one specimen.

*Dasymutilla macra* Fox

At *Andropogon scoparius—Bouteloua curtipendula* association, Council Bluffs, July 31, 1928, one specimen.

*Dasymutilla sparsa* Fox

At *Andropogon scoparius—Bouteloua curtipendula* association, 1 mi. north of Reels City, Aug. 1, 1928, one specimen.

*Ceropales fulvipes* Cress.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, June 18, 1926, one specimen.

*Ageniella annecta* Bks.

At *Stipa spartea—Andropogon scoparius* association, 7.75 mi. northwest of Thompson, May 18, 1928, one specimen.

*Ageniella atrata* Prov.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 29, 1925, one specimen.

*Priocnemis nothus* Cress.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Aug. 25, 1926, one specimen.

*Aporinellus laticeps* Bks.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, June 19, 1926, one specimen.

*Psammochares relativus* Fox (?)

At *Spartina* consocies, 2.5 mi. south of Ames, July 13, 1926, one specimen.

*Polistes variatus* Cress.

At *Silphium laciniatum* apparently gathering gum from a bruised spot on the plant, 2.5 mi. south of Ames, July 20, 1925, one specimen.

*Polistes pallipes* Le P.

From nest fastened to *Helianthus grosseserratus,* 10 mi. southwest of Ames, July 14, 1928, one specimen. From nest attached to *Amorpha canescens,* 1.5 mi. east of Verdi, Sept. 5, 1928, two specimens. Swept from flowers of *Cassia Chamaecrista,* Aug. 25, 1928, one specimen.

*Alyson trianguliferus* Prov.

At *Carex* socies, Lake Amana, June 23, 1928, one specimen.

*Nysson plagiatus* Cress.

At *Elymus virginicus,* 1 mi. south of Amana, Aug. 13, 1927, one specimen.

*Brachystegus* sp. near *trichrus* Mickel

At *Andropogon scoparius—Bouteloua curtipendula* association, 1 mi. north of Reels City, Aug. 1, 1928, one specimen.

*Psen cressoni* Pack.

At *Stipa spartea—Andropogon scoparius* association, 5 mi. south of Stanhope, Aug. 5, 1927, two specimens.

*Psen mellipes* Say

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Aug. 4, 1927, and Aug. 4, 1928, three specimens. At *Spartina* consocies, 8 mi. southeast of Britt, Aug. 9, 1928, two specimens.

*Oxybelus unicus* Mickel (?)

At *Andropogon scoparius—Bouteloua curtipendula* association, Sergeant Bluff, July 26, 1928, one specimen.

*Notoglossa emarginata* Say

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, June 28, 1926, one specimen.

*Crabro armaticeps* Fox

At *Helianthus grosseserratus*, Lake Amana, June 23, 1928, one specimen.

*Trypoxylon frigidum* Sm.

At *Spartina* consocies, Lake Amana, Aug. 12, 1927, one specimen.

*Didineis texana* Cress.

At *Polygonum amphibium* socies, 10 mi. southwest of Kelso, July 30, 1928, one specimen.

*Ammobia ichneumonea* Linn.

At flowers of *Cirsium iowense*, 2 mi. north of Ames, Aug. 13, 1926, one specimen. At flowers of *Solidago* sp., same locality, Sept. 17. 1926, one specimen.

*Sphex pictipennis* Walsh

At flowers of *Eryngium yuccifolium*, 2 mi. north of Ames, Aug 4 1926, one specimen.

*Sphex procera* Klug

At *Stipa spartea*—*Andropogon furcatus* association, 2 mi. north of Ames, Sept. 17, 1926, one specimen.

*Sphex urnarius* Dahlb.

At *Stipa spartea*—*Andropogon scoparius* association, 5 mi. south of Stanhope, Aug. 19, 1927, one specimen.

*Sphex varipes* Cress.

At *Andropogon scoparius*—*Bouteloua curtipendula* association, 1 mi. north of Reels City, Aug. 1, 1928, one specimen.

*Sceliphron caementarius* Dru.

At flowers of *Cicuta maculata*, 2.5 mi. south of Ames, July 6, 1926, one specimen.

*Lyroda subita* Say

At flowers of *Cicuta maculata*, 2.5 mi. south of Ames, July 15, 1926, and Aug. 4, 1928, two specimens.

*Larropsis distinctus* Smith

At flowers of *Solidago Riddellii*, 6 mi. south of Washington, Aug. 24, 1928, two specimens.

*Astata unicolor* Say

At flowers of *Cicuta maculata*, 2.5 mi. south of Ames, Aug. 4, 1928, one specimen.

*Bembex sayi* Cress.

At *Andropogon scoparius*—*Bouteloua curtipendula* association, Gitchie-Manito State Park, July 24, 1928, one specimen.

*Bembex spinolae* Le P.

At *Andropogon furcatus*—*Spartina Michauxiana* associes, 6 mi. northwest of Ledyard, Aug. 7, 1928, two specimens.

*Cerceris kennicothii* Cress.

At *Spartina* consocies, .5 mi. south of Missouri Valley, Aug. 1, 1928, one specimen.

*Cerceris venator* Cress.

At rest among flowers of *Asclepias verticillata,* 2.5 mi. south of Ames, Aug. 9, 1927, one specimen.

*Cerceris* sp. near *jacunda* Cr.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 10, 1925, one specimen.

*Cerceris compar* Cress. (?)

At flowers of *Cicuta maculata,* 5 mi. northwest of Buffalo Center, July 7, 1928, one specimen.

*Halictus provancheri* D. T.

At *Andropogon furcatus* consocies, *Stipa spartea—Andropogon scoparius* association, *Andropogon scoparius—Bouteloua curtipendula* association, and *Bouteloua hirsuta—Bouteloua curtipendula* association. Earliest adult, May 11, 1926; latest adult, Oct. 1, 1926. One specimen at flowers of *Zizia aurea,* and one at flowers of *Fragaria virginiana.* Common at *Bouteloua hirsuta—B. curtipendula,* and *Stipa spartea—Andropogon scoparius* associations.

*Halictus ligatus* Say

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, June 19, Aug. 9, 1926, and July 10, 1928; two specimens at flowers of *Silphium laciniatum,* and one at flowers of *Heliopsis scabra.* At flowers of *Silphium laciniatum,* 1 mi. south of Amana, July 20, 1928, one specimen.

*Halictus lerouxi* Le P.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, June 25, 1925, and May 7, 1926, two specimens. At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, June 29, 1926, one specimen.

*Halictus coriaceus* Smith

At flowers of *Anemone patens* var. *Wolfgangiana,* 2 mi. north of Ames, Apr. 21, 1926. At *Stipa spartea—Andropogon scoparius* association, same locality, May 9, 1926, one specimen.

*Halictus* sp. near *arcuatus* Robt.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, June 25, 1925, Aug. 4, 1926, two specimens.

*Halictus tegularis* Robt.

At *Andropogon scoparius—Bouteloua curtipendula* association, Oak Grove State Park, July 25, 1928, and 1 mi. north of Reels City, Aug. 1, 1928, two specimens. At *Polygonum amphibium* socies, .5 mi. south of Missouri Valley, Aug. 1, 1928, one specimen. At flowers of *Cassia Chamaecrista,* 1 mi. south of Amana, Aug. 25, 1928, one specimen.

*Halictus pilosus* Sm.

At *Andropogon furcatus* consocies, *Spartina* consocies, *Andropogon furcatus—Sorghastrum nutans* associes, and *Stipa spartea—Andropogon scoparius* association. Earliest adult, May 12, 1926; latest adult, Sept. 1,

1928. Taken at flowers of *Cicuta maculata, Pedicularis canadensis, Anemone patens* var. *Wolfgangiana, Rosa pratincola,* and *Coreopsis palmata.* Common.

*Halictus pruinosus* Robt.

At *Andropogon furcatus* consocies, *Spartina* consocies, and *Stipa spartea—Andropogon scoparius* association. Earliest adult, May 17, 1926; latest adult, Oct. 1, 1926. Taken at flowers of *Zizia aurea,* one specimen. Common at *Andropogon furcatus* and *Spartina* consocies.

*Halictus zephyrus* Smith

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Oct. 1, 1926, one specimen.

*Halictus nymphaearum* Robt.

At flowers of *Cicuta maculata,* 5 mi. northwest of Buffalo Center, July 7, 1928, three specimens. At *Andropogon furcatus* consocies, 5 mi. northwest of Buffalo Center, Sept. 16, 1928, two specimens.

*Halictus albipennis* Robt.

At *Andropogon furcatus—Spartina Michauxiana* associes, *Andropogon furcatus—Sorghastrum nutans* associes, *Stipa spartea—Andropogon scoparius* association, and *Bouteloua hirsuta—B. curtipendula* association. Earliest adult, May 15, 1926; latest adult, Oct. 1, 1926. Several specimens taken at flowers of *Rosa pratincola, Silphium laciniatum,* and *Veronica virginica.* Common at *Bouteloua hirsuta—B. curtipendula* association, *Stipa spartea—Andropogon scoparius* association, and *Andropogon furcatus* consocies.

*Halictus sparsus* Robt.

At *Andropogon furcatus—Spartina Michauxiana* associes, and *Andropogon scoparius—Bouteloua curtipendula* association. Earliest adult, May 17, 1926; latest adult, Aug. 1, 1928. Common at *Andropogon scoparius—Bouteloua curtipendula* association.

*Halictus versatus* Robt.

At flowers of *Silphium laciniatum,* and *Liatris pycnostachya,* 2.5 mi. south of Ames, July 27-Aug. 5, 1926, five specimens. At *Andropogon scoparius—Bouteloua curtipendula* association, 1 mi. west of Hamburg State Park, July 30, 1928, one specimen.

*Halictus coreopsis* Robt.

At flowers of *Heliopsis scabra,* 2.5 mi. south of Ames, July 10, 1928, one specimen.

*Halictus pictus* Cwfd.

At *Andropogon scoparius—Bouteloua curtipendula* association, Sergeant Bluff, July 26, 1928, one specimen.

*Halictus unicus* Sandhouse

At *Andropogon scoparius—Bouteloua curtipendula* association, 1 mi. west of Hamburg State Park, July 30, 1928, one specimen.

*Paralictus cephalicus* Robt.

At *Andropogon scoparius—Bouteloua curtipendula* association, Sergeant Bluff, July 26, 1928, one specimen.

*Agapostemum texanus* Cress.

At flowers of *Eryngium yuccifolium,* 2 mi. north of Ames, July 21, 1926, one specimen, and at flowers of *Silphium laciniatum,* July 29, 1926, one specimen. At flowers of *Silphium laciniatum,* 2.5 mi. south of Ames, July 29, 1926, two specimens. At flowers of *Oenothera serrulata,* 7.75 mi. northwest of Thompson, June 30, 1928, one specimen.

*Agapostemon texanus iowensis* Ckll.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, May 21, July 27, 1926, three specimens.

*Agapostemon virescens* Fabr.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, May 25, Oct. 1, 1926, and at flowers of *Silphium laciniatum,* same locality, June 21, 1926; four specimens.

*Augochlora confusa* Robt.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, July 21, 1926, two specimens.

*Augochlora pura* Say

At *Stipa spartea—Andropogon scoparius* association, *Andropogon furcatus* consocies, and *Spartina* consocies. Earliest adult, May 11, 1926; latest adult, Oct. 1, 1926. Taken at flowers of *Cirsium iowense, Silphium laciniatum, Eryngium yuccifolium,* and *Rosa pratincola.* One bee had been caught by an ambush bug (*Phymata erosa fasciata* Gray) on flowers of *Eryngium yuccifolium,* 2 mi. north of Ames, July 29, 1926.

*Sphecodes arvensis* Patt.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, July 1, 1926, one specimen.

*Sphecodes illinoiensis* Robt.

At flower of *Zizia aurea,* 2.5 mi. south of Ames, May 17, 1926, one specimen, and at *Stipa spartea—Andropogon furcatus* association, 2 mi. north of Ames, Oct. 1, 1926, one specimen.

*Protandrena asclepiadis* Ckll.

At *Andropogon scoparius—Bouteloua curtipendula* association, Sergeant Bluff, July 26, 1928, three specimens, and 1 mi. west of Hamburg State Park, July 30, 1928, one specimen.

*Andrena crawfordi* Vier.

At flowers of *Rosa pratincola,* 2 mi. north of Ames, June 22, 1926, one specimen.

*Andrena cressoni* Robt.

At flowers of *Ranunculus septentrionalis,* 2.5 mi. south of Ames, May 21, 1927, two specimens. At *Spartina* consocies, same locality, May 20, 1927, one specimen, and at *Andropogon furcatus* consocies, May 25, 1926, one specimen.

*Andrena flavoclypeata* Smith

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, May 19, 1926, one specimen.

*Macropis steironematis* Robt.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, June 23, 1925, one specimen.

*Macropis patellata* Patt.

At flowers of *Cicuta maculata,* 2.5 mi. south of Ames, July 6, 1926, one specimen.

*Perdita punctata* Ckll. (?)

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, June 23, 1925, one specimen.

*Panurginus innuptis* Ckll.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, June 28, 1926, one specimen.

*Calliopsis andreniformis* Sm.

At *Andropogon scoparius—Bouteloua curtipendula* association, 1 mi. north of Reels City, Aug. 1, 1926, one specimen.

*Nomada* sp. near *incerta* Cress.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, June 5, 1926, one specimen.

*Nomada* sp. near *illinoiensis* Robt.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, June 25, 1926, one specimen.

*Nomada articulata* Smith

At *Andropogon furcatus* consocies, 2 mi. north of Ames, July 2, 1926, one specimen.

*Nomada* sp. near *superba* Cress.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, May 20, 1926, one specimen.

*Epeolus* sp. near *autumnalis* Robt.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Aug. 7, 1925, one specimen.

*Pyrrhomelecta bifasciata* Cress.

At *Stipa spartea—Bouteloua curtipendula* association, 2 mi. north of Ames, July 6, 18, 1925. At flowers of *Lepachys pinnata,* July 31, 1926, one specimen.

*Triepeolus remigatus* Fabr.

At *Andropogon furcatus* consocies, 2 mi. north of Ames, Aug. 5, 1925, one specimen.

*Melissodes cnici* Robt.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Aug. 6, 1928, one specimen.

*Melissodes obliqua* Say

At flower of *Silphium laciniatum*, 2.5 mi. south of Ames, July 27, 1926, one specimen. At *Andropogon furcatus* consocies, same locality, Aug. 17, 1926, one specimen. At flowers of *Rudbeckia hirta*, 1 mi. south of Amana, July 20, 1928, one specimen.

*Melissodes* sp. near *pallidicincta* Ckll.

At flowers of *Solidago* sp., 2 mi. north of Ames, Sept. 24, 1926, one specimen.

*Melissodes rustica* Say

At *Bouteloua hirsuta—B. curtipendula* association, 2 mi. north of Ames, July 11, 1928, one specimen.

*Melissodes pennsylvanica* Lep.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 7, 1927, one specimen. At flowers of *Silphium laciniatum*, gathering pollen, same locality, Aug. 9, 1927, one specimen. At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, July 27, 1926, two specimens, one of which had been caught by an ambush bug (*Phymata erosa fasciata* Gray).

*Melissodes semiagilis* Ckll.

At *Stipa spartea—Andropogon scoparius* association, 5 mi. northwest of Thompson, July 7, 1928, one specimen.

*Tetralonia atriventris* Smith

At flowers of *Cirsium iowense*, 2 mi. north of Ames, Aug. 9, 25, 1926, eight specimens.

*Tetralonia frater* Cress.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, June 18, 22, 1926, two specimens.

*Tetralonia speciosa* Cress.

At *Andropogon furcatus* consocies, May 28, 31, June 19, 25, 1926, five specimens. At *Stipa spartea—Andropogon scoparius* association, 5 mi. south of Stanhope, June 15, 1928, one specimen.

*Hylaeus ziziae* Robt.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, July 16, 1925, one specimen.

*Colletes eulophi* (?) Robt.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, June 20, 1925, one specimen, and June 28, 1926, two specimens.

*Colletes latitarsis* Robt.

At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, July 28, 1925, one specimen.

*Colletes americanus* Cress.

At flowers of *Cicuta maculata,* 5 mi. northwest of Buffalo Center, July 7, 1928, one specimen.

*Colletes willistoni* Robt.

At *Andropogon scoparius—Bouteloua curtipendula* association, 15 mi. north of Sioux City, July 25, 1928, one specimen.

*Megachile brevis* Say

At flowers of *Liatris pycnostachya,* 2.5 mi. south of Ames, Aug. 11, 1927, one specimen. At *Apocynum androsaemifolium* family, 1 mi. south of Amana, June 23, 1928, one specimen.

*Megachile perbrevis* Cress.

At flowers of *Cicuta maculata,* 2.5 mi. south of Ames, July 6, 1926, one specimen. At flowers of *Liatris* sp., same locality, Aug. 2, 1926. At *Andropogon furcatus* consocies, same locality, June 26, July 26, 1926, one specimen.

*Megachile latimana* Say

At *Andropogon furcatus* consocies, on flowers of *Cirsium iowense,* 2 mi. north of Ames, Aug. 9, 1926, one specimen.

*Megachile inimica* Cress.

At *Bouteloua hirsuta—B. curtipendula* association, 5 mi. south of Stanhope, Sept. 19, 1928, one specimen.

*Holcopasites haematurus* Ckll. & Hicks

At *Andropogon scoparius—Bouteloua curtipendula* association, Sergeant Bluff, July 26, 1928, two specimens.

*Coelioxys sayi* Robt.

At *Stipa spartea—Andropogon scoparius* association, Sept. 24, 1926, one specimen. At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Aug. 11, 1925, one specimen.

*Ceratina dupla* Say

At *Bouteloua hirsuta—B. curtipendula* association, 2 mi. north of Ames, Apr. 18, 1927, one specimen.

*Bombus pennsylvanicus* De G.

At *Andropogon furcatus* consocies, 2.5 mi. south of Ames, Aug. 11, 1925, May 25, 1926, two specimens. At flowers of *Cirsium iowense,* 2 mi. north of Ames, Sept. 24, 1926. At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, Aug. 13, 1926, one specimen.

*Bombus auricomus* Robt.

At flowers of *Brauneria purpurea,* 2 mi. north of Ames, June 22, 1926, one specimen. At flowers of *Cirsium iowense,* same locality, Aug. 13, 1926, one specimen. At *Stipa spartea—Andropogon scoparius* association, 2 mi. north of Ames, June 19, 22, 1926, three specimens.

*Bombus separatus* Cress.

At *Andropogon furcatus—Sorghastrum nutans* associes, 1 mi. south of Amana, June 23, 1928, and Lacey-Keosauqua State Park, Aug. 22, 1928, two specimens. At flowers of *Asclepias purpurascens*, 2.5 mi. south of Ames, June 16, 1928, one specimen, and *Andropogon furcatus* consocies, same locality, May 12, 1927, two specimens. At *Spartina* consocies, Lake Amana, Aug. 12, 1927, two specimens.

*Bremus fervidus* Fabr.

At *Andropogon furcatus* consocies, 2 mi. south of Ledyard, May 9, 1926, one specimen. At *Stipa spartea—Andropogon scoparius* association, 7.75 mi. northwest of Thompson, May 18, 1928, one specimen.

*Bremus americanorum* Fabr.

At flowers of *Cassia Chamaecrista*, Aug. 12, 1927, 1 mi. south of Amana, four specimens.

*Apis mellifera* Linn.

At *Stipa spartea—Andropogon scoparius* association, northeast of Iowa State College grounds, July 11, 1928, one specimen. Other specimens have been observed at several communities.

SUMMARY

1. During the years 1925 to 1928, inclusive, insects representing 1175 determined species, subspecies and varieties were collected at 8 typical plant communities of less disturbed prairie, occurring at 40 localities in several parts of Iowa. Approximately 15,000 specimens were collected during the course of this work.

2. The following list contains the more common and numerous species at each plant community. The figure after a species signifies the number of other communities at which it was found to be common or numerous.

*Bouteloua hirsuta—B. curtipendula* (mesquite grass) association

Order *Orthoptera*

*Eritettix simplex, Ageneotettix deorum* (1), *Dissosteira carolina* (1), *Mestobregma kiowa kiowa* (1), *Encoptolophus sordidus, Hippiscus apiculatus, Melanoplus dawsoni* (2), *Phoetaliotes nebrascensis.*

Order *Hemiptera*

*Nysius ericae* (1), *Geocoris uliginosus limbatus* (3), *Ligyrocoris diffusus* (6), *Nabis ferus* (4), *Adelphocoris rapidus* (5), *Lygus pratensis* (2).

Order *Homoptera*

*Deltocephalus stylatus, Phlepsius altus* (1), *Scolops angustatus* (1).

Order *Coleoptera*

*Cicindela punctulata, Hippodamia tredecim-punctata* (7), *H. parenthesis* (7), *Aphodius distinctus* (6), *Trirhabda virgata* (4), *Diabrotica duodecimpunctata* (5), *D. longicornis* (4).

Order *Diptera*

*Mesogramma marginata* (7).

Order *Hymenoptera*

*Dorymyrmex pyramicus* (1), *Halictus provancheri* (2), *H. albipennis* (2).

*Andropogon scoparius—Bouteloua curtipendula* (beard grass—mesquite grass) association.

Order *Orthoptera*

*Diapheromera veliei* (3), *Pseudopomala brachyptera, Mermiria maculipennis macclungi, Ageneotettix deorum* (1), *Dissosteira carolina* (1), *Mestobregma kiowa kiowa* (1), *Hesperotettix pratensis, Melanoplus dawsoni* (2), *M. mexicanis atlanis, M. femur-rubrum* (4), *M. keeleri luridus* (3), *Arethaea gracilipes constricta, Conocephalus saltans* (3), *Nemobius fasciatus* (2), *Gryllus assimilis* (2), *Oceanthus nigricornis argentinus.*

Order *Hemiptera*

*Corimelaena agrella, Coenus delius* (1), *Neottiglossa sulcifrons, Ortholomus scolopax, Geocoris uliginosus limbatus* (3), *Ligyrocoris diffusus* (5), *Phymata erosa fasciata* (4), *Sinea diadema* (1), *Nabis ferus* (4), *Triphleps insidiosus* (3), *Adelphocoris rapidus* (5), *Polymerus basalis, Lygus pratensis* (2), *Coquillettia mimetica, Ilnacora divisa* (2).

Order *Homoptera*

*Philaronia bilineata, Stictocephala inermis* (1), *Vanduzea triguttata* (1), *Agallia sanguinolenta* (3), *Oncometopia lateralis, Gypona octolineata, Xerophloea viridis, Platymetopius cinereus, Driotura robusta, Euscelis anthracinus, E. striatulus* (1), *Phlepsius altus* (1), *Chlorotettix spatulatus, Scolops sulcipes* (3), *S. osborni, S. angustatus* (1), *S. pungens, Bruchomorpha dorsata, Acanalonia bivittata, Ormenis pruinosa, Pissonotus delicatus.*

Order *Coleoptera*

*Collops tricolor* (1), *Hippodamia tredecim-punctata* (7), *H. parenthesis* (7), *H. convergens* (6), *Coccinella novemnotata* (6), *Tetraopes femoratus amnicola, Nodonota tristis, Graphops varians, Trirhabda virgata* (4), *Anthonomus squamosus.*

Order *Lepidoptera*

*Cercyonis alope olympus* (3).

Order *Diptera*

*Psilocephala frontalis* (1), *Dolichopus bifractus* (6), *Mesogramma marginata* (7), *Coenosia lata* (6), *Ensina humilis* (4), *Euaresta bella* (6).

Order *Hymenoptera*

*Dorymyrmex pyramicus* (1), *Formica rufa obscuripe* var. *melanotica* (1), *Halictus provancheri* (2), *H. sparsus.*

*Stipa spartea—Andropogon scoparius* (porcupine grass—beard grass) association.

Order *Orthoptera*

*Diapheromera veliei* (3), *Orphulella speciosa, Chortophaga viridifasciata, Melanoplus dawsoni* (2), *M. femur-rubrum* (4), *M. keeleri luridus* (3), *Conocephalus saltans* (2), *Nemobius fasciatus* (2), *Gryllus assimilis* (2), *Oecanthus nigricornis quadripunctatus.*

Order *Hemiptera*

*Homaemus bijugis, Peribalus limbolarius* (2), *Trichopepla atricornis* (1), *Euschistus variolarius* (2), *Coenus delius* (1), *Alydus conspersus, A. pilosulus, Nysius ericae* (1), *Geocoris uliginosus limbatus* (3), *Sphaerobius insignis, Ligyrocoris diffusus* (5), *Zeridoneus costalis, Pseudocnemodus canadensis, Atheas mimeticus, Phymata erosa fasciata* (4), *Sinea diadema* (1), *Nabis subcoleoptratus, N. ferus* (4), *Triphleps insidiosus* (3), *Adelphocoris rapidus* (5), *Lygus pratensis* (2), *Lygus pratensis oblineatus* (3), *Lopidea media* (2), *L. teton, Ilnacora divisa* (2).

Order *Homoptera*

*Melampsalta calliope, Stictocephala inermis* (1), *Vanduzea triguttata* (1), *Publilia modesta, Campylenchia latipes, Agallia sanguinolenta* (2), *Draeculacephala mollipes* (2), *Parabolocratus viridis, Deltocephalus configuratus, D. inimicus* (2), *D. unicoloratus, Athysanella magdalena, Euscelis striatulus* (1), *E. comma* (2), *Chlorotettix unicolor, Scolops sulcipes* (3), *Aphalara veaziei.*

Order *Coleoptera*

*Eumolops sodalis, Chauliognathus pennsylvanicus* (2), *Epicauta trichrus, E. pennsylvanica* (2), *Phalacrus politus* (2), *Hippodamia tredecim-punctata* (7), *H. parenthesis* (7), *H. convergens* (6), *Coccinella novemnotata* (6), *Aphodius distinctus* (6), *Antipus laticlavia, Pachybrachys luridus, Nodonota puncticollis, Colaspis brunnea, Graphops curtipennis* (1), *Trirhabda virgata* (4), *Galerucella cribrata, Diabrotica duodecimpunctata* (4), *D. longicornis* (4), *Oedionychis thyamoides* (2), *Bruchus fraterculus, Rhynchites bicolor, Apion varicorne, Anametis granulata, Epicaerus imbricatus, Sitona tibialis, Baris striata.*

Order *Lepidoptera*

*Cercyonis alope olympus* (3), *Nephelodes albilinea* (1), *Papaipema arctivorens, P. cataphracta, P. eryngii, Crambus* sp. (1), *Tetralopha dolorosella* (2), *Sparganothis pallorana* (1).

Order *Diptera*

*Aedes vexans* (4), *Psilocephala frontalis* (1), *Leptogaster murinus, Promachus vertebratus* (2), *Dolichopus bifractus* (6), *Mesogramma marginata* (7), *Sphaerophoria cylindrica* (3), *Hylemyia cili-*

*crura, Coenosia lata* (6), *Limnia saratogensis* (5), *Ensina humilis* (4), *Euaresta bella* (6), *Meromyza americana* (1), *Diplotoxa versicolor, Ectecephala similis, Pholeomyia indecora.*

Order *Hymenoptera*

*Euplectrus comstocki, Myrmica scabrinodis* var. *subleti* (1), *Prenolepsis parvula, Lasius niger* var. *neoniger* (1), *L. latipes, Formica truncicola integroides, F. neogagates lasiodes* var. *vetula, F. neogagates* var. *vinculans, F. fusca* var. *argentea, F. rufa obscuripe* var. *melanotica* (1), *Halictus provancheri* (2), *H. pilosus* (3), *H. albipennis* (2), *Tetralonia atriventris, Bombus auricomus.*

*Andropogon furcatus—Sorghastrum nutans* (beard grass—wood grass) associes.

Order *Orthoptera*

*Diapheromera veliei* (3), *Melanoplus femur-rubrum* (4), *M. keeleri luridus* (3), *Conocephalus strictus* (1), *C. saltans* (3), *Oecanthus nigricornis quadripunctatus* (2).

Order *Hemiptera*

*Galgupha atra* (1), *Peribalus limbolarius* (2), *Euschistus variolarius* (2), *Alydus eurinus, Phlegyas abbreviatus, Ligyrocoris diffusus* (5), *Phymata erosa fasciata* (4), *Nabis ferus* (5), *Triphleps insidiosus* (3), *Adelphocoris rapidus* (5), *Lygus pratensis oblineatus* (3), *Lopidea media* (2), *Plagiognathus politus* (1).

Order *Homoptera*

*Publilia concava, Agallia sanguinolenta* (4), *Draeculacephala mollipes* (3), *Gypona melanota* (2), *Platymetopius frontalis, Deltocephalus sayi, D. inimicus* (3), *Euscelis comma* (3), *Scolops sulcipes* (4), *Aphelonema simplex* (1), *Acanalonia bivittata* (1).

Order *Coleoptera*

*Triaena angustata, Chauliognathus pennsylvanicus* (2), *Epicauta pennsylvanica* (2), *Phalacrus politus, Hippodamia tredecim-punctata* (7), *H. parenthesis* (7), *H. convergens* (6), *Coccinella novemnotata* (6), *C. sanguinea* (1), *Aphodius distinctus* (6), *Lema collaris, Nodonota convexa, Paria canella aterrima* (1), *P. canella sellata, Trirhabda virgata* (4), *Diabrotica duodecimpunctata* (4), *D. longicornis* (4), *Oedionychis thyamoides* (2), *Brachytarsus sticticus, Odontocorynus salebrosus* (1).

Order *Lepidoptera*

*Cercyonis alope olympus* (3), *Papaipema sciata* (1), *Eupithecia miserulata, Tetralopha dolorosella* (2), *Sparganothis pallorana* (1).

Order *Diptera*

*Promachus vertebratus* (2), *Dolichopus bifractus* (6), *Mesogramma marginata* (7), *Coenosia lata* (6), *Limnia saratogensis* (5), *Euaresta bella* (6).

Order *Hymenoptera*

*Lasius niger* var. *neoniger* (1), *Halictus pilosus* (3).

*Andropogon furcatus* (beard grass) consocies.

Order *Orthoptera*

*Diapheromera veliei* (3), *Acrydium ornatum* (1), *Tettigidea lateralis parvipennis* (1), *Orphulella speciosa* (1), *Chorthippus curtipennis* (1), *Chortophaga viridifasciata* (1), *Melanoplus femur-rubrum* (4), *M. keeleri luridus* (3), *M. differentialis* (1), *Scudderia texensis* (1), *Amblycorypha rotundifolia brachyptera, Neoconocephalus ensiger, Conocephalus fasciatus* (1), *C. strictus* (1), *C. saltans* (3), *Nemobius fasciatus* (2), *Gryllus assimilis* (2), *Oecanthus nigricornis quadripunctatus* (2).

Order *Hemiptera*

*Corimelaena pulicaria* (2), *Peribalus limbolarius* (2), *Trichopepla atricornis* (1), *Mormidea lugens* (1), *Euschistus variolarius* (2), *Nysius californicus, Geocoris uliginosus limbatus* (3), *Ligyrocoris diffusus* (6), *Phymata erosa fasciata* (4), *Nabis ferus* (4), *Triphleps insidiosus* (3), *Adelphocoris rapidus* (5), *Lygus pratensis oblineatus* (3), *Lopidea media* (2), *Ilnacora stalii* (1), *Plagiognathus politus* (1).

Order *Homoptera*

*Okanagana balli, Ceresa diceros, Acutalis semicrema, Agallia sanguinolenta* (3), *Draeculacephala mollipes* (2), *Gypona melanota* (1), *Dorycephalus platyrhynchus, Mesamia nigridorsum, Deltocephalus inimicus* (2), *Euscelis exitiosus, E. comma* (2), *Cicadula sexnotata, Scolops sulcipes* (3), *Aphelonema histrionica, Bipersona torticauda.*

Order *Coleoptera*

*Dyschirius globulosus, Lebia pumila* (1), *Stenolophus conjunctus* (1), *Lucidota nigricans* (1), *Chauliognathus pennsylvanicus* (2), *Collops quadrimaculatus, Epicauta pennsylvanica* (2), *Limonius propexus, Melanotus cribulosus, Acmaeodera pulchella, Carpophilus brachypterus, Languria mozardi, Phalacrus politus* (2), *Hyperaspis undulata, Hippodamia tredecim-punctata* (7), *H. parenthesis* (7), *H. convergens* (6), *Coccinella novemnotata* (6), *C. sanguinea* (1), *Aphodius distinctus* (6), *Typocerus sinuatus, Graphops pubescens, G. curtipennis* (1), *Trirhabda virgata* (4), *Diabrotica duodecimpunctata* (4), *D. longicornis* (4), *Oedionychis thyamoides* (2), *Systena elongata, Longitarsus testacens* (1), *Psylliodes punctulata, Microrphopala vittata, Baris deformis, Odontocorynus Salebrosus* (1).

Order *Lepidoptera*

*Cercyonis alope olympus* (3), *Nephelodes albilinea* (1), *Papaipema sciata* (1), *P. necopina, Tarachidia candefacta, Crambus elegans, Crambus sp.* (1), *Tetralopha dolorosella* (2), *Olethreutes hebesana, Sparganothis sulfureana.*

Order *Diptera*

*Limonia longipennis, Tanytarsus nigripalpus* (1), *Aedes vexans* (4), *Exoprosopa fasciata, Holcocephala abdominalis, Promachus* *vertebratus* (2), *Asilus erythrocnemius, A. paropus, Dolichopus bifractus* (6), *Empis nuda* (1), *Platychirus immarginatus* (1), *Allograpta obliqua, Mesogramma marginata* (7), *Sphaerophoria cylindrica* (3), *Coenosia lata* (6), *Schoenomyza dorsalis* (3), *Limnia saratogensis* (5), *Ensina humilis* (4), *Euaresta bella* (6), *Scatella stagnalis* (1), *Meromyza americana* (1).

Order *Hymenoptera*

*Pachynematus auratus, Crematogaster lineolata, Myrmica scabrinodis* subsp. or var. (1), *M. scabrinodis* var. *sabuleti* (1), *Tapinoma sessile* (1), *Formica pallide—fulva schaufussi, F. pallide—fulva* var. *incerta, Halictus pilosus* (3), *H. albipennis* (2), *H. pruinosus* (1), *H. versatus.*

*Spartina* (slough grass) consocies.

Order *Orthoptera*

*Acrydium ornatum* (1), *Tettigidea lateralis parvipennis* (1), *Chorthippus curtipennis* (1), *Melanoplus femur-rubrum* (4), *M. differentialis* (1), *Scudderia texensis* (1), *Orchelimum vulgare, O. nigripes, O. concinnum, Conocephalus fasciatus* (1), *C. attenuatus, Anaxipha exigua.*

Order *Hemiptera*

*Galgupha atra* (1), *Corimelaena pulicaria* (2), *Mormidea lugens* (1), *Podisus maculiventris* (1), *Protenor belfragei, Corizus bohemanii* (1), *Lygaeus bicrucis, Ischnodemus falicus, Ligyrocoris diffusus* (5), *Oedancala dorsalis, Phymata erosa fasciata* (4), *Nabis ferus pallidipennis, Trigonotylus tarsalis, Teratocoris discolor, Adelphocoris rapidus* (5), *Lygus pratensis oblineatus* (3), *L. campestris, Ilnacora divisa* (2), *I. stalii* (1).

Order *Homoptera*

*Cicadella hieroglyphica* var. *dolobrata, Draeculacephala noveboracencis, Kelisia crocea, Liburnia* near *osborni.*

Order *Coleoptera*

*Lebia viridis, Lebia pumila* (1), *Calleida punctata, Harpalus pleuriticus, Pseudamphasia sericea, Stenolophus conjunctus* (1), *Lucidota nigricans* (1), *Cantharis tantillus, Phalacrus politus* (2), *Coccidula lepida, Megilla maculata, Hippodamia tredecimpunctata* (7), *H. parenthesis* (7), *H. convergens* (6), *Coccinella novemnotata* (6), *Aphodius distinctus* (6), *Colaspis favosa* (1), *Paria canella aterrima* (1), *P. canella quadrinotata, Chrysochus auratus, Diabrotica duodecimpunctata* (4), *D. longicornis* (4), *Chalcoides fulvicornis nana, Longitarsus testaceus* (1), *Psylliodes punctulata, Hypera punctata.*

Order *Lepidoptera*

*Estigmene acraea* (1), *Ceramica picta* (1), *Cirphis unipuncta, Macronoctua onusta, Luperina stipata, Papaipema marginidens, Pyrausta futilalis.*

Order *Diptera*

*Helobia hybrida, Chironomus crassicaudata* (1), *C. lobiferus, Camptocladius byssinus* (1), *Cricotopus trifasciatus, C. trifasciatus* var. *tricinctus, Tanytarsus nigripalpus* (1), *Aedes vexans* (4), *Tabanus costalis, Psilopodinus sipho, Sciapus flavipes, Dolichopus bifractus* (6), *D. comatus, D. ramifer, Pelastoneurus vagans, Empis nuda* (1), *Platychirus immarginatus* (1), *Mesogramma marginata* (7), *Sphaerophoria cylindrica* (3), *Exorista nigripalpis, Coenosia lata* (6), *Schoenomyza dorsalis* (3), *Leptocera fontinalis, Tetanocera elata, Dictya umbrarum, Limnia saratogensis* (5), *Rivellia viridulans, Melieria ochricornis, Chaetopsis aenea, Ensina humilis* (4), *Euaresta bella* (6), *Sepsis violacea, Scatella stagnalis* (1).

Order *Hymenoptera*

*Myrmica scabrinodis* subsp. or var. (1), *Tapinoma sessile* (1), *Formica cinerea* var. *neocinerea, F. fusca* var. *subsericea, Halictus pilosus* (3), *H. pruinosus* (1).

*Carex* (sedge) socies.

Order *Homoptera*

*Thamnotettix melanogaster, Aphalara calthae.*

Order *Coleoptera*

*Hippodamia tredecim-punctata* (7), *H. parenthesis* (7), *H. convergens* (6), *Coccinella novemnotata* (6), *Aphodius distinctus* (6).

Order *Diptera*

*Chironomus crassicaudata* (1), *Camptocladius byssinus* (1), *Aedes vexans* (4), *Dolichopus bifractus* (6), *Mesogramma marginata* (7), *Coenosia lata* (6), *Schoenomyza dorsalis* (3), *Limnia saratogensis* (5), *Ensina humilis* (4), *Euaresta bella* (6).

*Polygonum amphibium* (smartweed) socies.

Order *Hemiptera*

*Podisus maculiventris* (1), *Corimelaena pulicaria* (2), *Corizus bohemanii* (1), *Adelphocoris rapidus* (6), *Deraeocoris histrio.*

Order *Homoptera*

*Ceresa bubalus, Phlepsius irroratus.*

Order *Coleoptera*

*Hippodamia tredecim-punctata* (7), *H. parenthesis* (7), *H. convergens* (6), *Coccinella novemnotata* (6), *Aphodius distinctus* (6), *Colaspis favosa* (1), *Diabrotica atripennis fossata, Systena frontalis, Lixus mucidus, L. terminalis, Ceutorhynchus sulcipennis, Rhinoncus pericarpius.*

Order *Lepidoptera*

*Estigmene acraea* (1), *Ceramica picta* (1).

Order *Diptera*

*Aedes vexans* (4), *Dolichopus bifractus* (6), *Mesogramma marginata* (7), *Sphaerophoria cylindrica* (2), *Coenosia lata* (6), *Schoenomyza dorsalis* (3), *Limnia saratogensis* (5), *Ensina humilis* (4), *Euaresta bella* (6).

3. Each of several plant communities was inhabited by a few species of insects which occurred in larger numbers and which were seldom or never found at any other community. These insects, in the following list, are suggested as the more distinctive species at the individual communities.

*Andropogon scoparius—Bouteloua curtipendula* (beard grass—mesquite grass) association.

Order *Orthoptera*

*Arethaea gracilipes constricta (Tettigoniidae).*

Order *Homoptera*

*Oncometopia lateralis (Cicadellidae), Pissonotus delicatus (Fulgoridae).*

*Stipa spartea—Andropogon scoparius* (porcupine grass—beard grass) association.

Order *Hemiptera*

*Alydus conspersus (Coreidae), Atheas mimeticus (Tingitidae), Lopidea teton (Miridae).*

Order *Homoptera*

*Deltocephalus configuratus (Cicadellidae).*

Order *Coleoptera*

*Anametis granulata (Curculionidae), Epicaerus imbricatus (Curculionidae), Sitona tibialis (Curculionidae).*

Order *Lepidoptera*

*Papaipema eryngii (Noctuidae).*

*Andropogon furcatus* (beard grass) consocies.

Order *Orthoptera*

*Amblycorypha rotundifolia brachyptera (Tettigoniidae).*

Order *Coleoptera*

*Systena elongata (Chrysomelidae), Microrhopala vittata (Chrysomelidae), Baris deformis (Curculionidae).*

Order *Hymenoptera*

*Formica pallide—fulva* var. *schaufussi (Formicidae).*

*Spartina* consocies.

Order *Hemiptera*

*Trigonotylus tarsalis (Miridae), Ischnodemus falicus (Lygaeidae).*

Order *Homoptera*

*Draeculacephala noveboracencis (Cicadellidae).*

*Polygonum amphibium* (smartweed) socies.

Order *Hemiptera*

*Deraeocoris histrio (Miridae).*

Order *Coleoptera*

*Diabrotica atripennis fossata (Chrysomelidae), Rhinoncus pericarpius (Curculionidae).*

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**PLATE I.**

**In the foreground, summer aspect of *Stipa spartea—Andropogon scoparius* association on the Hayden farm, two miles north of Ames.**

PLATE I.

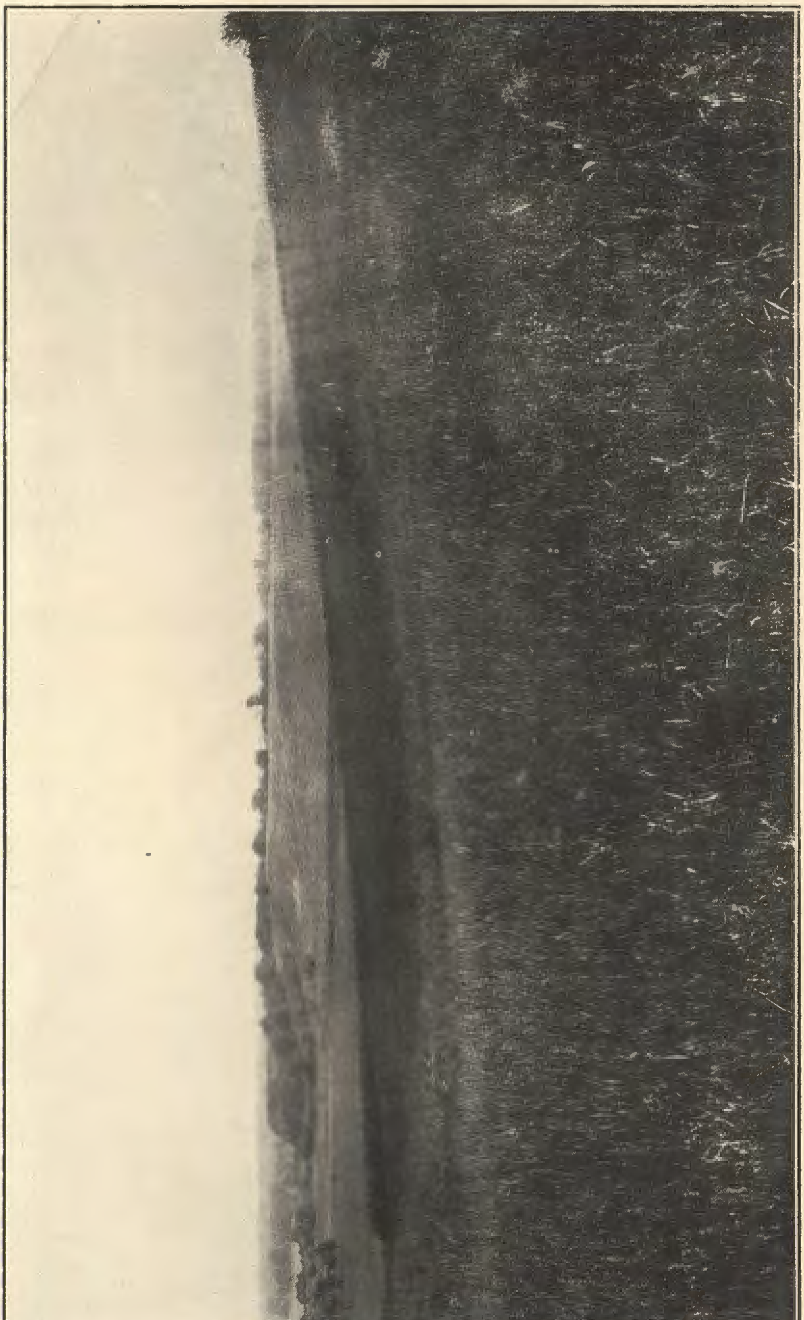

PLATE II.

*Andropogon furcatus—Spartina Michauxiana* associes on the Templeton farm, two and one-half miles south of Ames.

PLATE II.

# CLARIFICATION OF MILK FOR AMERICAN CHEDDAR CHEESE*

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The present yearly production of cheddar cheese in the world is approximately 660,000,000 pounds. On the basis of ten and one-half pounds of milk for a pound of cheese, the amount of milk used is 6,633,000,000 pounds. The yearly production of cheddar cheese in the United States is about 300,000,000 pounds, which is 45 per cent of the world's production, and 3,150,000,000 pounds of milk are required for this amount. Assuming the average wholesale price of cheese to be 22 cents a pound, the yearly value of the cheddar cheese made in this country is $66,000,000.

The activity of certain microörganisms is essential for the ripening of cheddar cheese, and accordingly conditions of manufacturing and curing favorable for their introduction and growth must be provided. These organisms should be present in the milk at the beginning of the manufacturing process, since in their absence at this stage certain undesirable types of bacteria, which may already be present, will probably develop and cause objectionable conditions. Abnormal odors and flavors are among the common defects in cheese due to microörganisms, while a pasty body and a mealy texture also may be caused by them.

Starters containing bacteria desirable for the ripening of cheese of the cheddar type have been used for many years in an attempt to control the fermentations occurring. Oftentimes, however, a starter may not have the desirable effect because of the activity of undesirable organisms that are already present in the milk, and which find the conditions provided favorable for their growth.

Pasteurization of milk is being used successfully in some foreign countries for the control of the fermentations brought about by bacteria in cheese. At present, pasteurization is being introduced in the United States, but raw milk is used for most of the cheese that is made.

The blending and processing of cheese has been used with success in this country during recent years for the production of a more nearly uniform and more easily marketable cheese.

## HISTORICAL

Attempts to remove the foreign material which gains entrance to the milk during its production and handling are made by means of various mechanical devices. The producer usually employs the more simple of

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these, such as wire screens or cotton cloths, while in the milk plants the more efficient forms such as filters and centrifugal clarifiers are used. Cream separators with the outlets so arranged that the cream and skim milk were mixed were first used for cleaning milk, while later specially constructed machines, such as clarifiers, were developed. The slime which is removed from milk by means of centrifugal force has been investigated with the object of determining the effect of the centrifugal force in a separator or clarifier on the numbers and types of bacteria present in the milk.

Doane (8), in discussing the economical methods for improving the keeping qualities of milk, states that it is doubtful who first used the separator for purifying milk, but that it is natural it should be used for this purpose, since anyone who has washed a separator has noticed a layer of matter that gathers on the inside of the steel bowl. He concluded, from some of his investigations, "that there is no doubt but that the separator removes the greater part of the dirt from milk. On the other hand, clarifying is valueless as a precaution against disease, and evidently has a tendency to cause the milk to sour more readily than when not so treated." He points out that milk which has been purified by the centrifugal methods was frequently called "clarified."

Grotenfelt (16), in studying the effect of centrifugal force on the numbers of bacteria in milk, found that in seven lots of milk centrifuging always resulted in decreases in the bacterial count. The counts on the unseparated milk ranged from 1,030 to 18,180, those on the skim milk from 220 to 11,025, and of the cream from 200 to 13,200 per c.c., while those of the separator slime ranged from 150,000 to 4,241,000 per c.c.

Hinkelmann (21) reported that from milk which had been inoculated with bouillon cultures of various organisms he was able to remove with a DeLaval clarifier from 57 to 96 per cent, with an average of 78 per cent. He believed that small or gram-positive organisms were of a greater density than the ordinary milk bacteria.

Dunbar and Kister (10), in working with a Heine cleaning centrifuge of the hollow bowl type in which there was a filter cloth, found that the running of milk through the machine caused no particular changes in the milk, as shown by the specific gravity, and solids not-fat content of the milk before and after it had been cleaned. They found many bacteria in the slime, but their conclusions indicate that the chief function of the machine lies in the removal of dirt particles and foreign matter.

Fleischmann (15) quotes Hueppe, who asserts that "most of the organisms, and among these the most dangerous ones, remain behind in the separator residue,' but Fleischmann doubts that centrifuging has this effect.

Eckles and Barnes (11) were among the first to study the effect of centrifugalization of milk upon the number of bacteria present. In each of seven experiments they found that when running milk through a separator, the milk contained from 15 to 51 per cent fewer organisms after centrifuging than before. They also found that when separating milk an average of "29 per cent of the total number of organisms went into the skim milk, 24 per cent into the cream, and about 47 per cent into the slime."

Bahlman (3), in eight tests found that the unclarified milk averaged 1,312,000, and the clarified milk 1,670,000 bacteria per c.c. The increases in the counts due to clarification ranged from 9 to 60 per cent and averaged 27 per cent. He states that the increases were due to the breaking apart of bacterial clumps by the mechanical action of the clarifier.

McClintock (30) studied the effect of clarification on the number of bacteria in milk in 59 trials in city plants using three different types of clarifiers. The unclarified milk contained from 54,000 to 2,650,000 bacteria per c.c. and the clarified milk from 36,000 to 12,000,000. Sometimes clarification caused an increase and sometimes a decrease in the count, but increases occurred in only three trials. McClintock (31) also clarified sterile milk which had been inoculated with lactic acid bacteria or with pathogenic organisms. Clarification resulted in a decrease of from 15.3 to 16.1 per cent in the number of acid formers and of from 95.8 to 99 per cent in the pathogenic organisms.

Hammer (17), in working with a DeLaval clarifier, found that the plate counts of the clarified milk were commonly, although not constantly, higher than those of the unclarified milk. Since the clarifier slime which he examined contained large numbers of bacteria, and contamination of the milk was excluded, he accounts for the increase in the counts as a result of clarification by the breaking up of clumps of organisms due to centrifuging. This investigator is of the opinion that "whether there will be an increase or a decrease in the apparent number of organisms during clarification probably depends on the types of organisms and on the presence of clumps." Working with a Sharples clarifier, Hammer (18) later obtained results which were in the main comparable to the earlier data.

McInerney (32) studied the effect of clarification on high and low count milk. In 28 lots of low count milk, the unclarified milk contained an average of 8,410, and the clarified milk 15,739 bacteria per c.c., the increases in the counts due to clarification varied from 1.76 to 415.1 per cent and averaged 87.15 per cent. In 17 lots of high count milk the unclarified milk contained an average of 9,778,191, and the clarified milk 21,000,694 bacteria per c.c., while the increases due to clarification ranged from 5.82 to 1574.7 and averaged 114.77 per cent.

When studying the production of sanitary milk, Sherman (38), in 15 tests found that unclarified milk contained an average of 3,640 and clarified milk an average of 7,020 bacteria per c.c.; in four tests the methylene blue test showed a quicker reduction with the clarified milk. In continuing his work he (39) later found that in 24 tests the average bacterial count of unclarified milk was 4,720 and of clarified milk 7,120 per c.c. In eight tests the unclarified milk reduced methylene blue, on an average, in 15.5 hours, while the clarified milk reduced it in 17.9 hours.

Marshall and Hood (27) found that "in market milk, the number of organisms is usually increased after clarification, as revealed by the plating method. This is doubtless due to disruption of colonies." They also observed that the clarifier was able to eliminate bacteria in "no small degree, but no differentiation between pathogens and non-pathogens can be made."

In a later article Marshall and Hood (28) report that the clarifier had effected eliminations of from 24 to 99 per cent of bacteria from milk, the large organisms and colonies of organisms being removed most readily. Pure cultures of bacteria were used in this work.

Dahlberg and Marquardt (6), in their report on the effect of clarification on the bacterial content of milk, summarize as follows: "With one exception the official plate count was decreased in milk with a count below 100,000 per c.c., but there was a tendency to increase the count of milk with more than 100,000 as a result of clarification. A decrease in the size of bacterial clumps in clarified milk of low count was shown by direct microscopic examination.''

Traum and Hart (41) found that milk which had been naturally infected with tubercle bacilli, after having been clarified in a large milk plant, caused tuberculosis in guinea pigs which were inoculated with it.

Marpman (26) reports the tubercle organisms to be of about the same specific gravity as normal milk, varying from 1.018 to 1.046.

Moore (33) artificially infected milk with tubercle bacilli from glycerol bouillon and blood serum cultures at the rate of 7 c.c. to 4000 c.c. of milk, and found that after running this through a hand separator the skim milk and cream both caused tuberculosis when inoculated into guinea pigs. He repeated the experiment with other pathogenic organisms and found the bacteria in the skim milk.

## STATEMENT OF THE PROBLEM

The magnitude of the industry warrants the introduction of improved methods of manufacture, and it was for the purpose of determining the effect of clarification on the quality of cheddar cheese that the work herein reported was undertaken.

The studies were divided into two parts. The first deals with the effect of clarification on the numbers and types of bacteria present in milk and was carried out for the purpose of determining whether or not the effect of clarification on the bacteria in milk is such as to suggest an influence on the quality of cheese obtained from the milk. The second involves the making and study of cheese from unclarified and clarified milk from the same lot.

The work has been conducted for several years. Part of the cheese was made in Utah and part of it in Iowa. Therefore, it has been possible to study the effect of clarification under different conditions.

## PART I. THE EFFECT OF CLARIFICATION ON THE BACTERIA IN MILK

Since the numbers and types of bacteria present in milk may show considerable variation, an extended study of the effect of clarification on the flora of milk was undertaken. The investigation involved determinations of the effect of clarification on the numbers and types of bacteria in milk using a normal and tenth-normal rate of inflow; these were intended to show whether or not the clarifier had a selective action on the organisms. A study of the types of bacteria in clarifier slime and in the sediment obtained from milk which had been centrifuged in tubes also was included. Because of their use in cheese factories in determining the quality of milk, the methylene blue reduction test and the fermentation test were compared with the plate count from the standpoint of showing the changes caused by clarification. A study was made of the size and specific gravity of the organisms which appeared to be eliminated by the clarifier and an attempt made to classify them.

### METHODS

The milk used for the bacteriological work was that received by the Dairy Department of the Iowa State College. No attempt was made to select any of the milk, but in all cases that which was studied represented the general milk supply. Care was taken always to steam all parts of the equipment with which the milk was to come in contact. The milk was well agitated in a 100-gallon coil vat before clarification, and was then pumped through a short line of sanitary pipe to the clarifier. A DeLaval No. 105 clarifier was used throughout the experiments. The clarified milk samples were taken after at least ten gallons of milk had run through the clarifier to reduce all possible contamination from the pump, pipe, or clarifier, and also to be sure that the clarifier was working normally. The samples of milk were transferred to sterile tubes by means of sterile pipettes. Whenever the samples were to be held for some time, they were placed in ice water as soon as collected to prevent multiplication of the bacteria. Various clarification temperatures were used during the earlier part of the investigational work in order to determine at what temperature the clarifier caused the least change in the physical condition of the milk. It was found that when clarifying at temperatures from 15.5° to 37.8°C. (60° to 100°F.) considerable foam, rich in fat, was formed, while at temperatures from 10° to 15.5°C. (50° to 60°F.) the physical state of the milk was not materially influenced. Therefore, it was decided to clarify the milk at the temperatures at which it was received, which were generally about 12.8°C. (55°F.). Ordinarily, the clarifier was operated at a normal capacity, but in a number of trials the rate of inflow was reduced to about one-tenth normal.

In the preparation of the clarifier slime for plating, a representative sample was taken from the clarifier bowl by means of a sterile spatula and placed in a sterile mortar. The slime was thoroughly triturated with sterile water until it formed a homogeneous viscous material. A small amount of this was then transferred to a water blank and plates poured after the proper dilutions had been made.

Beef infusion agar, containing 1.5 per cent shred agar and 0.5 per cent peptone, adjusted to a reaction of plus 1.0 Fuller's scale, was used for all the counts. This medium was chosen because it was desired to use one which would be most favorable for the growth of the bacteria in the milk. Duplicate plates were prepared, which were incubated at 37°C. (98.6°F.) for two days.

In the study of the types of bacteria present in unclarified and clarified milk and in the slime, 50 contiguous colonies from representative areas on the plates were picked into sterile litmus milk. These cultures were kept at room temperature for ten days, and then classified into the following groups: acid coagulators, acid non-coagulators, inert, alkali producers, and neutral, alkali, and acid peptonizers.

The method used for the methylene blue reduction test was that recommended in the Standard Methods of Milk Analysis (40). The samples used for the methylene blue test were also used for the fermentation test; the tubes were kept for six days at room temperature for observations on the character of the fermentations occurring.

## RESULTS

### 1. *Influence of Clarification on the Number of Bacteria in Milk*

In the study of the influence of clarification on the number of bacteria in milk, 43 comparisons of unclarified and clarified milk were made, using the plate method. Table 1 gives the bacterial counts obtained and the percentage change in numbers due to clarification. The counts on the unclarified milk ranged from 15,300 to 1,240,000 per c.c. Clarification caused an increase in the bacterial count in 20 trials and a decrease in 23. The increases in the counts varied from 3.1 to 143.7 per cent and averaged 54.6 per cent, while the decreases varied from 0.4 to 59.1 per cent and averaged 24.9 per cent. Considering the 43 comparisons, there was an average increase of 12.1 per cent as a result of clarification.

The increases due to clarification as determined by the plate count are only apparent, since there was no appreciable contamination, and are accounted for by the breaking up of bacterial clumps and chains by the clarifier.

TABLE 1. *Influence of Clarification on the Number of Bacteria in Milk.*

| Date | | | Bacteria per c.c. | | Percentage | |
|---|---|---|---|---|---|---|
| | | | Unclarified | Clarified | Increase | Decrease |
| 1926 | Nov. | 8 | 19,000 | 27,000 | 42.1 | |
| | | 12 | 27,500 | 45,000 | 63.6 | |
| | | 15 | 137,000 | 136,500 | | .4 |
| | | 19 | 21,500 | 45,000 | 109.3 | |
| | | 22 | 32,500 | 22,150 | | 31.8 |
| | | 29 | 29,000 | 54,000 | 86.2 | |
| | Dec. | 11 | 79,500 | 82,000 | 3.1 | |
| | | 13 | 88,000 | 102,000 | 15.9 | |
| | | 15 | 138,500 | 159,000 | 14.8 | |
| | | 14 | 558,000 | 532,000 | | 4.6 |
| | | 18 | 15,300 | 27,800 | 81.6 | |
| | | 20 | 66,500 | 105,000 | 57.9 | |
| 1927 | Jan. | 5 | 199,000 | 116,000 | | 41.7 |
| | | 7 | 297,000 | 250,000 | | 15.8 |
| | | 8 | 53,000 | 45,000 | | 15.1 |
| | | 10 | 134,500 | 130,500 | | 3.0 |
| | | 12 | 45,500 | 43,000 | | 5.5 |
| | | 14 | 21,000 | 39,500 | 88.1 | |
| | | 15 | 322,000 | 139,200 | | 56.7 |
| | | 17 | 185,000 | 176,500 | | 4.6 |
| | | 19 | 50,500 | 43,000 | | 14.8 |
| | | 22 | 17,200 | 15,800 | | 8.1 |
| | | 24 | 44,000 | 18,000 | | 59.1 |
| | | 26 | 199,000 | 97,500 | | 51.0 |
| | | 29 | 146,000 | 215,000 | 47.2 | |
| | Feb. | 7 | 53,500 | 50,000 | | 6.5 |
| | | 11 | 147,000 | 128,000 | | 12.9 |
| | | 14 | 800,000 | 400,000 | | 50.0 |
| | | 15 | 1,240,000 | 970,000 | | 21.8 |
| | | 18 | 78,000 | 86,000 | 10.2 | |
| | | 19 | 252,000 | 266,000 | 5.6 | |
| | | 22 | 225,000 | 339,000 | 50.7 | |
| | | 23 | 390,000 | 460,000 | 17.9 | |
| | | 25 | 320,000 | 780,000 | 143.7 | |
| | | 26 | 400,000 | 290,000 | | 27.5 |
| | | 28 | 103,000 | 149,000 | 44.7 | |
| | Mar. | 2 | 48,000 | 63,000 | 31.3 | |
| | | 4 | 75,000 | 111,000 | 48.0 | |
| | | 5 | 380,000 | 360,000 | | 5.3 |
| | | 7 | 42,000 | 97,000 | 130.9 | |
| | | 11 | 540,000 | 305,000 | | 43.5 |
| | | 12 | 530,000 | 330,000 | | 37.7 |
| | | 14 | 805,000 | 370,000 | | 54.0 |

An analysis of the data given in table 1, shows that 23 of the 43 counts on unclarified milk were higher than 100,000 per c.c., and 20 were lower. With the 23 counts above 100,000 per c.c., clarification caused a decrease in 16, or 70 per cent, and an increase in seven, or 30 per cent, while with the 20 samples of milk showing counts lower than 100,000 per c.c. clarification caused a decrease in 7, or 35 per cent, and an increase in 13, or 65 per cent. This shows that with the milk studied, clarification was more likely to cause a decrease in the count when the milk contained over 100,000 bacteria per c.c. than when it contained a smaller number. Other investigators report similar results, although the available data show considerable variations.

### 2. *Influence of Clarification With Normal and With Reduced Rate of Inflow on the Number of Bacteria in Milk.*

A comparison was made of the influence of clarification on the number of bacteria in milk, using a normal and a tenth-normal rate of inflow. The plate counts obtained and the percentage change in numbers with 19 lots of milk are shown in table 2.

TABLE 2. *Influence of Clarification With Normal and With Reduced Rates of Inflow on the Number of Bacteria in Milk.*

| Date | Unclarified | Normal inflow | | Reduced inflow | |
|---|---|---|---|---|---|
| | (Bact. per c.c.) | (Bact. per c.c.) | Pct. decrease | Bact. per c.c. | Pct. decrease |
| 1927 Mar. 26 | 1,730,000 | 1,620,000 | 6.3 | 1,060,000 | 38.7 |
| Apr. 5 | 2,100,000 | 1,930,000 | 8.1 | 580,000 | 72.4 |
| Apr. 6 | 1,520,000 | 1,090,000 | 28.3 | 360,000 | 76.3 |
| Apr. 7 | 59,000 | 57,000 | 3.4 | 20,500 | 65.2 |
| Apr. 8 | 64,000 | 52,000 | 18.7 | 16,000 | 75.0 |
| Apr. 9 | 46,500 | 41,500 | 10.8 | 16,500 | 64.5 |
| Apr. 11 | 170,000 | 180,000 | —5.9 | 82,000 | 51.7 |
| Apr. 12 | 230,500 | 343,000 | —48.8 | 128,000 | 44.4 |
| Apr. 13 | 1,850,000 | 1,070,000 | 42.1 | 417,000 | 77.4 |
| Apr. 14 | 27,000 | 44,500 | —64.8 | 17,000 | 37.0 |
| Apr. 15 | 90,000 | 79,000 | 12.2 | 47,000 | 47.3 |
| Apr. 16 | 1,220,000 | 1,600,000 | —31.1 | 710,000 | 41.8 |
| Apr. 28 | 770,000 | 960,000 | —24.7 | 570,000 | 25.9 |
| Apr. 29 | 3,710,000 | 2,920,000 | 21.2 | 1,670,000 | 55.0 |
| May 2 | 5,310,000 | 2,110,000 | 60.2 | 2,040,000 | 61.5 |
| May 3 | 2,230,000 | 2,010,000 | 9.9 | 435,000 | 80.5 |
| May 4 | 1,220,000 | 855,000 | 29.9 | 595,000 | 51.1 |
| May 5 | 83,500 | 113,000 | —35.3 | 52,000 | 37.7 |
| May 7 | 600,000 | 485,000 | 19.1 | 320,000 | 46.7 |

The counts on the unclarified milk ranged from 27,000 to 5,310,000 per c.c. When the rate of inflow was normal, clarification caused an increase in the count in six trials, and a decrease in 13, but when the rate of inflow was reduced, clarification always caused a decrease. With the normal rate of inflow there was a minimum increase in the counts of 5.9 per cent, a maximum of 64.8, and an average of 35.1, while the minimum decrease was 3.4 per cent, the maximum 60.2, and the average 20.8; considering the 19 comparisons there was an average decrease of 3.1 per cent. When the rate of inflow was reduced there was a minimum decrease of 25.9 per cent, a maximum of 80.5, and an average of 55.3. These data show that by decreasing the rate of inflow it was possible to remove, on an average, more than half of the bacteria present in milk.

Thirteen of the 19 samples of milk contained more than 100,000 bacteria per c.c., while six had less. With the 13 counts above 100,000 per c.c. clarification with the normal rate of inflow caused a decrease in nine, or 70 per cent, and an increase in four, or 30 per cent, while with the six counts below 100,000 per c.c. there was a decrease in four or 67 per cent, and an increase in two, or 33 per cent. The milk used for these trials contained on an average more bacteria than did the milk used for these trials reported in table 1. However, the results obtained in both series of determinations with the milk containing more than 100,000 bacteria per c.c. check very closely.

TABLE 3. *Types of Bacteria Present in Unclarified and Clarified Milk.*

| Date | | Percentage: Acid | | Inert | Alkali | Peptonizers | | |
|---|---|---|---|---|---|---|---|---|
| | | Coagulators | Non-coagulators | | | Neutral | Acid | Alkali |
| 1926 Nov. 8 | Uncl. | 49.1 | 16.3 | 16.3 | 14.3 | 2.0 | 2.0 | 0 |
| | Cl. | 83.4 | 9.3 | 5.4 | 1.9 | 0 | 0 | 0 |
| 12 | Uncl. | 10.9 | 60.9 | 15.2 | 2.2 | 4.3 | 6.5 | 0 |
| | Cl. | 10.6 | 61.7 | 19.1 | 4.3 | 0 | 4.3 | 0 |
| 15 | Uncl. | 29.6 | 37.0 | 12.9 | 13.0 | 0 | 5.6 | 1.9 |
| | Cl. | 40.4 | 42.4 | 1.9 | 11.5 | 0 | 1.9 | 1.9 |
| 19 | Uncl. | 43.7 | 23.0 | 16.6 | 14.6 | 0 | 0 | 2.1 |
| | Cl. | 20.0 | 44.0 | 28.0 | 8.0 | 0 | 0 | 0 |
| 22 | Uncl. | 10.0 | 52.0 | 10.0 | 24.0 | 0 | 0 | 4.0 |
| | Cl. | 10.0 | 50.0 | 18.0 | 20.0 | 0 | 0 | 2.0 |
| Dec. 6 | Uncl. | 53.8 | 23.1 | 0 | 15.4 | 0 | 7.7 | 0 |
| | Cl. | 39.6 | 30.1 | 7.7 | 11.3 | 1.9 | 9.4 | 0 |
| Nov. 29 | Uncl. | 30.0 | 18.0 | 10.0 | 40.0 | 0 | 2.0 | 0 |
| | Cl. | 24.0 | 22.0 | 10.0 | 38.0 | 0 | 6.0 | 0 |
| Dec. 11 | Uncl. | 42.0 | 14.0 | 14.0 | 22.0 | 0 | 8.0 | 0 |
| | Cl. | 44.0 | 38.0 | 0 | 14.0 | 0 | 4.0 | 0 |
| 13 | Uncl. | 14.5 | 12.3 | 10.2 | 59.0 | 2.0 | 2.0 | 0 |
| | Cl. | 12.0 | 22.0 | 4.0 | 60.0 | 0 | 0 | 2.0 |
| 3 | Uncl. | 86.0 | 10.0 | 0 | 4.0 | 0 | 0 | 0 |
| | Cl. | 85.7 | 8.2 | 2.1 | 2.0 | 0 | 2.0 | 0 |
| 4 | Uncl. | 86.0 | 10.0 | 0 | 4.0 | 0 | 0 | 0 |
| | Cl. | 96.0 | 0 | 0 | 4.0 | 0 | 0 | 0 |
| 18 | Uncl. | 10.2 | 40.8 | 22.5 | 26.5 | 0 | 0 | 0 |
| | Cl. | 10.0 | 40.0 | 20.0 | 30.0 | 0 | 0 | 0 |
| 20 | Uncl. | 22.0 | 24.0 | 8.0 | 40.0 | 0 | 6.0 | 0 |
| | Cl. | 52.0 | 22.0 | 4.0 | 18.0 | 0 | 4.0 | 0 |
| 1927 Jan. 5 | Uncl. | 24.0 | 16.0 | 8.0 | 32.0 | 0 | 20.0 | 0 |
| | Cl. | 20.0 | 34.0 | 2.0 | 36.0 | 0 | 8.0 | 0 |
| 7 | Uncl. | 7.8 | 7.8 | 2.0 | 39.2 | 0 | 43.2 | 0 |
| | Cl. | 10.0 | 22.0 | 0 | 38.0 | 0 | 30.0 | 0 |
| 8 | Uncl. | 13.7 | 31.4 | 19.6 | 5.9 | 0 | 29.4 | 0 |
| | Cl. | 14.0 | 40.0 | 18.0 | 6.0 | 2.0 | 20.0 | 0 |
| 10 | Uncl. | 4.0 | 22.0 | 6.0 | 50.0 | 0 | 18.0 | 0 |
| | Cl. | 0 | 28.0 | 4.0 | 50.0 | 2.0 | 16.0 | 0 |
| 12 | Uncl. | 16.0 | 20.0 | 2.0 | 24.0 | 2.0 | 36.0 | 0 |
| | Cl. | 18.0 | 20.0 | 4.0 | 40.0 | 4.0 | 14.0 | 0 |
| 14 | Uncl. | 8.0 | 36.0 | 12.0 | 32.0 | 2.0 | 10.0 | 0 |
| | Cl. | 16.0 | 40.0 | 12.0 | 24.0 | 0 | 8.0 | 0 |
| 17 | Uncl. | 24.0 | 24.0 | 16.0 | 18.0 | 0 | 18.0 | 0 |
| | Cl. | 30.0 | 22.0 | 10.0 | 28.0 | 0 | 10.0 | 0 |
| Feb. 14 | Uncl. | 36.0 | 36.0 | 4.0 | 16.0 | 0 | 8.0 | 0 |
| | Cl. | 56.0 | 20.0 | 10.0 | 10.0 | 4.0 | 0 | 0 |

### 3. *The Effect of Clarification on the Types of Bacteria Present in Milk.*

The results of a study of the types of bacteria present in 21 lots of milk before and after clarification are reported on a percentage basis in table 3. The data show that the acid forming groups predominated in both the unclarified and clarified milk, while the neutral and acid peptonizers were the least numerous. Sometimes the acid coagulators were present in larger numbers than the acid non-coagulators, and sometimes the reverse was true. Separation of the acid formers into two groups on the basis of whether or not coagulation occurs is of questionable importance since with certain of the *Streptococcus lactis* organisms (19) the rate of coagulation of litmus milk is a character which may undergo definite fluctuations. In a few comparisons the alkali formers were present in large numbers in the unclarified milk, but they were present also in considerable numbers in the milk after clarification. Whenever a certain group of organisms was present in the unclarified milk, it was present nearly always in the clarified milk, although there was usually a change in the percentage. The results show that clarification caused increases and decreases in the per-

TABLE 4. *The Types of Bacteria Present in Unclarified Milk and in the Slime Obtained from It.*

| Date | | Percentage | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Acid | | | | Peptonizers | | |
| | | Coagulators | Non-coagulators | Inert | Alkali | Neutral | Acid | Alkali |
| 1926 Dec. 11 | U.* | 42.0 | 14.0 | 14.0 | 22.0 | 0 | 8.0 | 0 |
| | Sl.** | 41.4 | 12.0 | 0 | 46.6 | 0 | 0 | 0 |
| 18 | U. | 10.2 | 40.8 | 22.5 | 26.5 | 0 | 0 | 0 |
| | Sl. | 3.9 | 11.7 | 21.6 | 62.8 | 0 | 0 | 0 |
| 1927 Jan. 5 | U. | 24.0 | 16.0 | 8.0 | 32.0 | 0 | 20.0 | 0 |
| | Sl. | 22.7 | 0 | 0 | 75.0 | 0 | 0 | 2.3 |
| 7 | U. | 7.8 | 7.8 | 2.0 | 39.2 | 0 | 43.2 | 0 |
| | Sl. | 20.0 | 14.0 | 0 | 64.0 | 0 | 2.0 | 0 |
| 8 | U. | 13.7 | 31.4 | 19.6 | 5.9 | 0 | 29.4 | 0 |
| | Sl. | 3.9 | 23.5 | 31.4 | 19.6 | 0 | 21.6 | 0 |
| 12 | U. | 16.0 | 20.0 | 2.0 | 24.0 | 2.0 | 36.0 | 0 |
| | Sl. | 4.0 | 14.0 | 0 | 68.0 | 2.0 | 12.0 | 0 |
| 14 | U. | 8.0 | 36.0 | 12.0 | 32.0 | 2.0 | 10.0 | 0 |
| | Sl. | 28.0 | 16.0 | 10.0 | 32.0 | 0 | 14.0 | 0 |
| 15 | U. | 68.6 | 15.7 | 3.9 | 5.9 | 0 | 5.9 | 0 |
| | Sl. | 20.0 | 2.0 | 0 | 74.0 | 0 | 4.0 | 0 |
| 17 | U. | 24.0 | 24.0 | 16.0 | 18.0 | 0 | 18.0 | 0 |
| | Sl. | 58.3 | 0.0 | 2.0 | 35.4 | 0 | 4.3 | 0 |
| 19 | U. | 4.0 | 6.0 | 22.0 | 30.0 | 2.0 | 36.0 | 0 |
| | Sl. | 8.0 | 2.0 | 2.0 | 82.0 | 0 | 6.0 | 0 |
| 22 | U. | 34.0 | 26.0 | 4.0 | 26.0 | 0 | 10.0 | 0 |
| | Sl. | 12.0 | 58.0 | 2.0 | 22.0 | 0 | 6.0 | 0 |
| 24 | U. | 14.0 | 14.0 | 4.0 | 54.0 | 0 | 14.0 | 0 |
| | Sl. | 46.0 | 14.0 | 0 | 40.0 | 0 | 0 | 0 |
| 26 | U. | 42.0 | 2.0 | 0 | 54.0 | 0 | 2.0 | 0 |
| | Sl. | 26.0 | 72.0 | 0 | 0 | 0 | 0 | 2.0 |
| 29 | U. | 52.0 | 20.0 | 5.0 | 13.0 | 0 | 10.0 | 0 |
| | Sl. | 57.4 | 0 | 0 | 12.8 | 0 | 29.8 | 0 |
| Feb. 7 | U. | 53.0 | 13.7 | 11.8 | 17.6 | 0 | 3.9 | 0 |
| | Sl. | 26.0 | 6.0 | 2.0 | 64.0 | 0 | 2.0 | 0 |
| 11 | U. | 90.0 | 2.0 | 0 | 8.0 | 0 | 0 | 0 |
| | Sl. | 76.0 | 8.0 | 2:0 | 14.0 | 0 | 0 | 0 |

TABLE 4. *Continued.*

| Date | | Percentage | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Acid | | | | Peptonizers | | |
| | | Coagulators | Non-coagulators | Inert | Alkali | Neutral | Acid | Alkali |
| 1926 Feb. 12 | U. | 98.0 | 2.0 | 0 | 0 | 0 | 0 | 0 |
| | Sl. | 98.0 | 0 | 0 | 2.0 | 0 | 0 | 0 |
| 14 | U. | 36.0 | 36.0 | 4.0 | 16.0 | 0 | 8.0 | 0 |
| | Sl. | 26.0 | 26.0 | 2.0 | 44.0 | 0 | 2.0 | 0 |
| 15 | U. | 82.0 | 16.0 | 0 | 2.0 | 0 | 0 | 0 |
| | Sl. | 42.0 | 12.0 | 6.0 | 26.0 | 0 | 14.0 | 0 |
| 18 | U. | 82.0 | 2.0 | 0 | 12.0 | 0 | 4.0 | 0 |
| | Sl. | 40.0 | 2.0 | 4.0 | 54.0 | 0 | 0 | 0 |
| 19 | U. | 74.0 | 12.0 | 0 | 8.0 | 0 | 6.0 | 0 |
| | Sl. | 90.0 | 4.0 | 0 | 4.0 | 0 | 2.0 | 0 |
| 22 | U. | 10.0 | 56.0 | 0 | 24.0 | 0 | 10.0 | 0 |
| | Sl. | 10.0 | 60.0 | 0 | 26.0 | 0 | 4.0 | 0 |
| 23 | U. | 90.0 | 0 | 6.0 | 2.0 | 0 | 2.0 | 0 |
| | Sl. | 84.0 | 0 | 2.0 | 10.0 | 0 | 4.0 | 0 |
| 25 | U. | 88.0 | 0 | 2.0 | 10.0 | 0 | 0 | 0 |
| | Sl. | 88.0 | 0 | 0 | 12.0 | 0 | 0 | 0 |
| 26 | U. | 100.0 | 0 | 0 | 0 | 0 | 0 | 0 |
| | Sl. | 64.0 | 12.0 | 10.0 | 8.0 | 0 | 6.0 | 0 |
| 28 | U. | 72.0 | 16.0 | 8.0 | 4.0 | 0 | 0 | 0 |
| | Sl. | 30.0 | 16.0 | 16.0 | 24.0 | 0 | 14.0 | 0 |
| Mar. 2 | U. | 12.0 | 82.0 | 6.0 | 0 | 0 | 0 | 0 |
| | Sl. | 34.0 | 20.0 | 10.0 | 30.0 | 0 | 6.0 | 0 |
| 4 | U. | 50.0 | 40.0 | 0 | 4.0 | 0 | 6.0 | 0 |
| | Sl. | 38.0 | 24.0 | 6.0 | 24.0 | 0 | 8.0 | 0 |
| 5 | U. | 90.0 | 10.0 | 0 | 0 | 0 | 0 | 0 |
| | Sl. | 74.0 | 10.0 | 2.0 | 10.0 | 2.0 | 2.0 | 0 |
| 7 | U. | 32.0 | 52.0 | 4.0 | 2.0 | 0 | 8.0 | 2.0 |
| | Sl. | 26.0 | 68.0 | 2.0 | 2.0 | 0 | 2.0 | 0 |
| 11 | U. | 46.0 | 20.0 | 2.0 | 20.0 | 8.0 | 4.0 | 0 |
| | Sl. | 32.0 | 20.0 | 4.0 | 38.0 | 2.0 | 4.0 | 0 |
| 12 | U. | 22.0 | 8.0 | 4.0 | 34.0 | 4.0 | 28.0 | 0 |
| | Sl. | 2.0 | 4.0 | 0 | 80.0 | 4.0 | 10.0 | 0 |
| 14 | U. | 66.0 | 10.0 | 4.0 | 10.0 | 10.0 | 0 | 0 |
| | Sl. | 34.0 | 52.0 | 8.0 | 4.0 | 2.0 | 0 | 0 |

*Unclarified.
**Slime.

centages of the various groups, but did not cause a consistent elimination of any single group.

When one considers that milk consists of various complex substances and that the bacteria present may show daily variations both in numbers and in types, it would be expected that the effect of clarification would be variable. The changes caused by clarification were not significant enough to warrant any conclusions regarding a selective action of the clarifier.

An analysis of the data given in table 3 shows that clarification caused increases in the groups approximately as often as decreases, with the exception of the acid peptonizers, which were decreased in 82.4 per cent of the comparisons in which they were present in the original milk, but since these organisms were present in the milk in comparatively small numbers, the significance of this is not great. ~~On the average, the acid coagulators were increased, and the alkali formers decreased by clarification.~~ This is of particular interest because of later studies on the types of bacteria present in clarifier slime.

4. *The Types of Bacteria Present in Unclarified Milk and in the Slime Obtained from It.*

Although the results obtained in section 3 did not indicate any selective action by the clarifier on the bacteria present in milk, it was decided to study this further under conditions favorable for determining such an effect. A study of the types of bacteria present in unclarified milk and in the slime obtained from it was made, because if the clarifier has any selective influence on the bacteria in the milk, this should be quite evident from the types of bacteria present in the slime. The results of 33 comparisons are reported on a percentage basis in table 4. The data show that the types of bacteria present in the milk, in general, were the same as those present in the slime. The types of bacteria present in the milk were similar to those present in the unclarified milk studied in section 3. The acid coagulators usually predominated, but sometimes the acid non-coagulators were the most numerous; the neutral and alkali peptonizers were the least prominent. In the slime the acid formers usually predominated, although occasionally the alkali formers were the most prominent, while the neutral and alkali peptonizers were present in the smallest percentages. Wide variations were noted in the percentages of acid coagulators and alkali formers present, but no regular elimination of either of these two groups from the milk seems to have taken place.

A comparison of the differences in the types of bacteria present in the milk and in the slime is shown in table 5, together with a summary of these differences. The only groups which showed a fairly consistent change as a result of clarification were the acid coagulators and the alkali formers. The average changes were 8.7 per cent decrease in the acid formers and a 16.8 per cent increase in the alkali formers in the slim as compared with those present in the milk. Whether these changes were actually brought about by the clarifier is difficult to say. As has already been pointed out, clarification slightly increased the percentage of acid coagulators in the milk and decreased the percentage of alkali formers. This would suggest that there should be a corresponding decrease and increase in the same groups in the slime, and the figures shown in table 5 indicate that such a change did take place. The summary of the changes shows that an increase and a decrease occurred in the various groups of organisms, the most consistent decrease occurring in the acid forming and the most consistent increase in the alkali forming groups.

The average change of the acid coagulators is about three times and that of the alkali formers about twenty times as great as the probable error of the mean, while the average changes of the other groups are in the same order of magnitude as the probable error of the mean. This would indicate that the change in the alkali-forming group had considerable significance and the change in the acid coagulating group some significance. From the theory of probability the chances are slight that the changes in these two groups were due to experimental error.

Microscopic examinations of the slime showed the presence of many gram-positive clumps and chains of bacteria of varying size, as well as numerous gram-positive and gram-negative organisms, isolated and in pairs. Large gram-negative rods were abundant; they were usually pres-

TABLE 5. *Differences in the Types of Bacteria Present in Unclarified Milk and in the Slime Obtained from It.*

| Date | | Changes in the types of organisms in the slime as compared with the types present in unclarified milk | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Acid Coagulators | | Acid non-coagulators | | Inert | | Alkali | | Neut. pept. | | Acid pept. | | Alk. pept. | |
| | | Increase | Decrease | Increase | Decrease | Increase | Decrease | Increase | Decrease | Increase | Decrease | Increase | Decrease | Increase | Decrease |
| 1926 Dec. | 11 | | 0.6 | | 2.0 | | 14.0 | 24.6 | | | | | 8.0 | | |
| | 18 | | 6.3 | | 29.1 | | 0.9 | 36.3 | | | | | | | |
| 1927 Jan. | 5 | | 1.3 | | 16.0 | | 8.0 | 43.0 | | | | | 20.0 | 2.3 | |
| | 7 | 12.2 | | 6.2 | | | 2.0 | 24.8 | | | | | 41.2 | | |
| | 8 | | 9.8 | | 7.9 | 11.8 | | 13.7 | | | | | 7.8 | | |
| | 12 | | 12.0 | | 6.0 | | 2.0 | 44.0 | | 0 | 0 | | 24.0 | | |
| | 14 | 20.0 | | | 20.0 | | 2.0 | 0 | 0 | | 2.0 | 4.0 | | | |
| | 15 | | 48.6 | | 13.7 | | 3.9 | 68.1 | | | | | 1.9 | | |
| | 17 | 34.3 | | | 24.0 | | 14.0 | 17.4 | | | | | 13.7 | | |
| | 19 | 4.0 | | | 4.0 | | 20.0 | 52.0 | | | 2.0 | | 30.0 | | |
| | 22 | | 22.0 | 32.0 | | | 2.0 | | 4.0 | | | | 4.0 | | |
| | 24 | 32.0 | | 0 | 0 | | 4.0 | | 14.0 | | | | 14.0 | | |
| | 26 | | 16.0 | 70.0 | | | | | 54.0 | | | | 2.0 | 2.0 | |
| | 29 | 5.4 | | | 20.0 | | 5.0 | | 0.2 | | | 19.8 | | | |
| Feb. | 7 | | 27.0 | | 7.7 | | 9.8 | 46.4 | | | | | 1.9 | | |
| | 11 | | 14.0 | 6.0 | | 2.0 | | 6.0 | | | | | | | |
| | 12 | 0 | 0 | | 2.0 | | | 2.0 | | | | | | | |
| | 14 | | 10.0 | | 10.0 | | 2.0 | 28.0 | | | | | 6.0 | | |
| | 15 | | 40.0 | | 4.0 | 6.0 | | 24.0 | | | | 14.0 | | | |
| | 18 | | 42.0 | 0 | 0 | 4.0 | | 42.0 | | | | | 4.0 | | |
| | 19 | 16.0 | | | 8.0 | | | | 4.0 | | | | 4.0 | | |
| | 22 | 0 | 0 | 4.0 | | | | 2.0 | | | | | 6.0 | | |
| | 23 | | 6.0 | | | | 4.0 | 8.0 | | | | 2.0 | | | |
| | 25 | 0 | 0 | | | | 2.0 | 2.0 | | | | | | | |
| | 26 | | 36.0 | 12.0 | | 10.0 | | 8.0 | | | | 6.0 | | | |
| | 28 | | 42.0 | 0 | 0 | 8.0 | | 20.0 | | | | 14.0 | | | |
| Mar. | 2 | 22.0 | | | 62.0 | 4.0 | | 30.0 | | | | 6.0 | | | |
| | 4 | | 12.0 | | 16.0 | 6.0 | | 20.0 | | | | 2.0 | | | |
| | 5 | | 16.0 | 0 | 0 | 2.0 | | 10.0 | | 2.0 | | 2.0 | | | |
| | 7 | | 6.0 | 16.0 | | | 2.0 | 0 | | | 0 | | 6.0 | | 2.0 |
| | 11 | | 14.0 | 0 | 0 | 2.0 | | 18.0 | | | 6.0 | 0 | 0 | | |
| | 12 | | 20.0 | | 4.0 | | 4.0 | 46.0 | | 0 | 0 | | 18.0 | | |
| | 14 | | 32.0 | 42.0 | | 4.0 | | | 6.0 | | 8.0 | | | | |
| Av. change | | | 8.7 | | 2.2 | | 1.4 | 16.8 | | | 2.3 | | 5.1 | 0.7 | |
| | | | $\sigma = 26.9$ p.e. $= 17.8$ p.e.$_m$ $= 3.16$ | | $\sigma = 22.6$ p.e. $= 15.0$ p.e.$_m$ $= 2.69$ | | $\sigma = 7.55$ p.e. $= 4.95$ p.e.$_m$ $= 0.947$ | | $\sigma = 7.16$ p.e. $= 4.8$ p.e.$_m$ $= 0.846$ | | $\sigma = 5.65$ p.e. $= 3.78$ p.e.$_m$ $= 1.44$ | | $\sigma = 18.21$ p.e. $= 12.2$ p.e.$_m$ $= 2.56$ | | $\sigma = 1.96$ p.e. $= 1.31$ p.e.$_m$ $= 0.76$ |

TABLE 5. *Continued.*

Summary of the changes in the various groups

| | Increase | | Decrease | | No change | |
|---|---|---|---|---|---|---|
| | Times | Per cent | Times | Per cent | Times | Per cent |
| Acid coagulators | 8 | 24.2 | 22 | 66.7 | 3 | 9.1 |
| Acid non-coag. | 8 | 25.8 | 18 | 58.1 | 5 | 16.1 |
| Inert | 11 | 37.9 | 18 | 62.1 | 0 | 0 |
| Alkali | 25 | 75.7 | 6 | 18.2 | 2 | 6.1 |
| Neut. Pept. | 1 | 14.3 | 4 | 57.1 | 2 | 28.6 |
| Acid Pept. | 9 | 32.1 | 18 | 64.3 | 1 | 3.6 |
| Alkali Pept. | 2 | 66.7 | 1 | 33.3 | 0 | 0 |

ent in pairs, and corresponded in morphology and staining reaction to those of the alkali formers which had been isolated from plates.

The changes in the percentages of acid and alkali formers may have been due to a selective action of the clarifier. They may also have been due to a breaking-up of bacterial clumps and chains by the clarifier, while the increase in the percentage of alkali formers may be accounted for by assuming that these organisms were associated with the cells and dirt particles in the milk, and since these, for the most part, were removed in the slime, the organisms would be removed with them. However, this latter explanation is not entirely logical, because if the alkali formers were held by the cells and dirt they should practically all have been removed, while the data show that on an average the slime contained only 16.8 per cent more of these organisms than the unclarified milk.

The results obtained in this study seem to justify the conclusion, that if the clarifier had a selective action on the bacteria present in the milk used, the alkali formers were the ones responding to this influnce.

5. *The Effect of Clarification With Normal and Reduced Rate of Inflow on the Types of Bacteria Present in Milk.*

In order to study the effect of prolonged exposure of milk to centrifugal force in a clarifier on the types of bacteria present, a series of 18 comparisons was made in which a normal and a one-tenth normal rate of inflow were used. The primary object was to see if it was possible, by means of a greater clarifying efficiency, to cause a significant change in the flora of the milk. The data obtained showed that the acid formers predominated in both the unclarified milk and in the milk clarified with either method of clarification while the neutral and alkali peptonizers were the least numerous.

The results agree with those obtained in section 3. The types of bacteria present in the clarified milk were similar to those in the unclarified milk. Although there were slight variations in the types present, no great elimination of any of the groups took place.

6. *The Effect of Clarification With Normal and Reduced Rate of Inflow on the Bacteria in Milk, as Determined by the Plate Count, the Methylene Blue Test and the Fermentation Test.*

A series of determinations of the effect of clarification on the bacteria in milk with a normal and with a reduced rate of inflow was made, using the plate count, the methylene blue test, and the fermentation test. The data obtained in nine comparisons are shown in table 6.

**TABLE 6.** ***The Effect of Clarification with Normal and Reduced Rate of Inflow on the Bacteria in Milk, as Determined by the Plate Count, the Methylene Blue Test, and the Fermentation Test.***

Plate count

| Date | | | Unclarified (bacteria per c.c. | Clarified: Normal inflow (bacteria per c.c.) | Percentage decrease | Reduced Inflow (bacteria per c.c.) | Percentage decrease |
|---|---|---|---|---|---|---|---|
| 1927 | May | 25 | 700,000 | 470,000 | 32.9 | 140,000 | 80.0 |
| | | 26 | 1,035,000 | 745,000 | 28.0 | 560,000 | 45.9 |
| | June | 20 | 3,310,000 | 1,980,000 | 40.2 | 550,000 | 83.4 |
| | | 21 | 7,530,000 | 6,600,000 | 12.3 | 700,000 | 12.3 |
| | | 22 | 2,780,000 | 1,890,000 | 32.0 | 1,090,000 | 60.8 |
| | July | 6 | 615,000 | 475,000 | 22.8 | 350,000 | 43.1 |
| | | 7 | 2,820,000 | 2,580,000 | 8.5 | 1,060,000 | 62.4 |
| | | 8 | 750,000 | 580,000 | 22.6 | 330,000 | 56.0 |
| | | 9 | 920,000 | 750,000 | 18.5 | 270,000 | 70.7 |
| | | | | | Av. 24.2 | | Av. 57.2 |

Methylene blue test

| Date | | | Unclarified (minutes to reduce) | Clarified: Normal inflow (minutes to reduce) | Increase in reduction time due to clarification (min.) | Reduced inflow (minutes to reduce) | Increase in reduction time due to clarification (min.) |
|---|---|---|---|---|---|---|---|
| 1927 | May | 25 | 135 | 180 | 45 | 210 | 75 |
| | | 26 | 235 | 255 | 20 | 285 | 50 |
| | June | 20 | 90 | 105 | 15 | 135 | 45 |
| | | 21 | 60 | 90 | 30 | 120 | 60 |
| | | 22 | 165 | 210 | 45 | 240 | 75 |
| | July | 6 | 240 | 240 | 0 | 270 | 30 |
| | | 7 | 120 | 140 | 20 | 180 | 60 |
| | | 8 | 210 | 210 | 0 | 210 | 0 |
| | | 9 | 210 | 225 | 15 | 240 | 30 |
| | | | | | Av. 21 | | Av. 47 |

Fermentation test

| Date | | | Unclarified | Clarified (character of curd): Normal inflow | Reduced inflow |
|---|---|---|---|---|---|
| 1927 | May | 25 | Sl. liq. near surface of curd | Solid curd | Sl. liq. near surface of curd |
| | | 26 | Solid curd | Solid curd | Solid curd |
| | June | 20 | Sl. gassy | Sl. gassy | Sl. gassy |
| | | 21 | Solid curd | Solid curd | Solid curd |
| | | 22 | Gassy | Gassy | Gassy |
| | July | 6 | Badly gassy | Badly gassy | Badly gassy |
| | | 7 | Gassy | Sl. gassy | Gassy |
| | | 8 | Gassy | Gassy | Gassy |
| | | 9 | Sl. gassy | Sl. gassy | Sl. gassy |

The bacterial counts were quite high, on an average. Clarification always resulted in a decrease in the counts. There was an average decrease of 24.2 per cent when a normal rate of inflow was used, and an average decrease of 57.2 per cent when a one-tenth normal rate of inflow was used. The reduction time of the unclarified milk ranged from 60 to 240 minutes and averaged 163 minutes, that of the normally clarified milk ranged from

90 to 255 minutes and averaged 184 minutes, while that of milk clarified with a reduced rate of inflow ranged from 120 to 285 minutes and averaged 210 minutes. With the normal rate of inflow, clarification caused an increase in the reduction time in seven trials and no change in two and with the reduced rate of inflow it caused an increase in eight trials and no change in one. The greatest increase in the time with the normal inflow was 45 minutes and with the reduced inflow 75 minutes. The average increases when all comparisons are considered were 21 minutes with normal clarification and 47 minutes with clarification involving a reduced rate of inflow.

The data would indicate that clarification with both rates of inflow resulted in most cases in a noticeable increase in the reduction time. There seems to be no definite correlation, however, between the counts of the unclarified or clarified milk and the reduction time when the counts for the different runs are considered. Since clarification always resulted in a decrease in the counts in this particular series, these data are therefore not applicable to runs where clarification results in an increase.

The results obtained by the methylene blue test agreed, in general, with those obtained by the plate method. It would seem, however, that the plate method was the more refined in showing the differences in the numbers of bacteria of milk caused by clarification.

The reason why the methylene blue test does not show relatively small differences in the numbers of bacteria in milk, may be accounted for by the differences in the ability of various types of bacteria to decolorize methylene blue and to the variations in their development.

The observations of the fermentation test would indicate that clarification had no influence on the type of fermentation taking place, whether a normal or a reduced rate of inflow was used. The character of the curd which formed from the clarified milk, in all cases, was similar to that which formed from the unclarified milk.

### 7. *Comparison of the Effect of Centrifugal Force on the Numbers and Types of Organisms Present in Uncentrifuged Milk, and in the Sediment Obtained in Centrifuge Tubes.*

In order to obtain some additional data on the effect of centrifugal force on milk, tests were made in which 15 c.c. samples of uncentrifuged milk were placed in conical tubes and centrifuged at room temperature for varying periods of time; the speed was 1900 revolutions per minute and the circle through which the outer edge of the tubes passed was 15 inches. The sediment was then diluted to 15 c.c. with sterile water and the numbers and types of organisms determined.

The data obtained showed that in a series of four comparisons, after five minutes centrifuging, a minimum of 5.8, a maximum of 20.2, and an average of 12.6 per cent of the total numbers of bacteria present in the milk were in the sediment, while after the milk had been exposed to centrifugal force for 20 minutes a minimum of 9.5, a maximum of 29.9, and an average of 16.7 per cent were in the slime.

The results of a study of the types of bacteria present in uncentrifuged milk and in the sediment obtained from it after centrifuging samples of milk of the same lot for 5, 20 and 30 minutes, respectively, in four comparisons, and for 5 and 20 minutes in four other comparisons showed that the acid formers were usually the most numerous types in both the milk and in the sediment, but sometimes the alkali formers or acid peptonizers were the most prominent. Centrifuging caused some slight variations in the types, but whenever a certain type was present in the milk it was usually found in the sediment. Even prolonged exposure of the milk to centrifugal force did not consistently cause a complete elimination of any of the types present in the milk.

It would seem that the exposure of milk to centrifugal force in tubes, even for a considerable time, did not materially affect the flora of the milk.

Although centrifuging of the naturally infected milk did not cause much change in the types of organisms present, it was decided to study the effect of centrifugal force on samples of low count milk heavily inoculated with large alkali forming bacteria or with yeasts obtained from agar slope cultures. Raw milk was used in preference to sterile milk because in the latter some of the constituents are changed physically and chemically by the heating process. In all cases, both with the alkali formers and with the yeasts, centrifuging for one-half hour caused a decrease in the numbers present. The number of organisms present in the milk and cream layer after these had been mixed, when added to the numbers in the sediment, should equal the total number of organisms present in the milk before centrifuging. This, as a rule, did not occur, probably due to a clumping of the organisms in the sediment, since microscopic examination of the sediment showed the presence of large numbers of clumps of the inoculated organisms.

8. *The Specific Gravity of Yeasts and Alkali Forming Bacteria.*

An attempt was made to determine the specific gravity of some of the alkali producing organisms isolated because of their relative abundance in the slime. The specific gravity of a still larger organism, *Torula cremoris,* also was determined.

The alkali formers were grown in Petri dishes on beef infusion agar, while beef extract agar containing lactose was used for the yeast. Usually the growth obtained from eight or ten dishes was employed in each determination. As soon as a good growth had occurred this was carefully scraped off with a sharp steel blade and transferred quickly to a tared, dry, 25 c.c. pycnometer. Whenever the growth was sufficient, duplicate determinations were made. The specific gravity was determined by comparing the weight of a certain volume of the organisms with the weight of an equal volume of distilled water at the same temperature. In making the determinations, four different weighings were made, as follows: the dry pycnometer, the pycnometer plus the bacterial growth, the pycnometer filled with distilled water, and the pycnometer filled with the bacterial growth and distilled water. The specific gravity of the bacterial growth was obtained by dividing the weight of this as determined by subtraction by the weight of the volume of water which it displaced; the latter represented the difference between the weight of the water containing organisms and the weight of distilled water necessary to fill the pycnometer. In two determinations plain bouillon was used as a medium for the alkali formers. Five hundred c.c. lots of this were inoculated, and when a good growth had occurred they were centrifuged in 50 c.c. tubes; the sediment obtained was then placed in pycnometers and the specific gravity determined.

With *Torula cremoris* the values obtained ranged from 1.037 to 1.102, with an average of 1.079. With the alkali formers, when agar was the medium, the values ranged from 1.029 to 1.123, with an average of 1.0497, but when bouillon was used the specific gravities were 1.025 and 1.032, with an average of 1.0285.

The duplicate determinations sometimes showed variation. The smallest difference between checks was 0.003, the largest 0.019, and the average of the seven runs where checks were made was 0.009. The growth obtained from ten plates usually weighed about one gram, but even with heavy growth the amount obtained was too small for accurate determinations.

The results, of course, cannot be directly applied to milk because of the variations in the composition and size of bacteria grown in different kinds of media. If the specific gravities of the alkali formers, as they occur in milk, are similar to those obtained when they are grown on agar and in bouillon, it would seem that it would be difficult, considering the short exposure to the centrifugal force, for the clarifier to remove a large percentage of them.

### 9. *Comparison of Morphological, Cultural and Biochemical Characteristics of Alkali Forming Bacteria.*

The relative abundance of the alkali forming bacteria in the clarifier slime suggested the isolation and study of organisms of this type. The arbitrary grouping of these organisms on the basis of their ability to produce alkali in milk does not indicate that they possess other characteristics in common, and for this reason a more detailed study of these bacteria would be expected to lead to a division of them into groups or types. From several hundred litmus milk cultures of alkali forming bacteria obtained in the investigation of the types of bacteria present in milk and in clarifier slime, 31 were selected. After having been purified by plating and picking, the organisms were studied on the basis of morphology, staining reaction, motility, growth in or on various media, gelatin liquefaction, reaction changes in media, and the production of indol and nitrite.

The microscopic examination of the 31 cultures showed that when the organisms were grown in litmus milk at either room temperature or 37°C. (98.6°F.) they were medium to large, plump, rod-shaped, non-spore forming, gram-negative organisms, having rounded ends and arranged in pairs, but when they were grown on infusion agar at both the above temperatures the cells were much smaller and almost spherical. Motility was regularly noted. Growth always occurred near the surface when milk or bouillon was used as a medium and only on the surface with agar stabs. At room temperature and at 37°C. (98.6°F.) the growth on 24-hour agar slopes was moderate, white, filiform, glistening, and slightly raised, while after two weeks the growth was abundant, grey-white, filiform, and in most cases raised. A yellowish-brown growth occurred on potato slants. None of the organisms liquefied gelatin. When grown in plain bouillon or bouillon containing glycerol, dextrose, galactose, levulose, lactose, sucrose, maltose, mannitol, or raffinose (reaction plus 0.05 Fuller's scale), an alkaline reaction was always produced after one week as shown by the change in color which appeared on the addition of a few drops of brom-thymol blue indicator to each tube. Indol was not produced in any of the cultures. Two cultures showed nitrite production.

It would seem from the study of these cultures of alkali formers, that, in general, their main characteristics were similar; they were probably varieties of one species of organisms. Therefore, a separation of them into groups was not made.

## PART II. THE INFLUENCE OF CLARIFICATION ON THE QUALITY OF CHEESE

The study of the effect of clarification on the quality of cheese involved the use of 23,000 pounds of milk, representing both unclarified and clarified milk from 67 different lots. Additional trials were carried out in which cheese made from unclarified milk was compared with that obtained from clarified milk to which clarifier slime or pure cultures of alkali forming bacteria had been added. A total of 145 batches of cheese was made, of which 48 were made in Utah and 97 in Iowa.

In a few comparisons the bacterial flora of the ripened cheese was studied for the purpose of determining whether or not it had been modified by clarification.

### HISTORICAL

Up to the present time clarification of milk for cheddar cheese has not been generally employed by cheese factories in the United States. However, the process is being used to some extent in the manufacture of Swiss cheese.

Matheson (29) found that centrifuging the milk resulted in an increase in the higher grades of Swiss cheese. The cheese made from centrifuged milk did not have a flavor different than that made from untreated milk, but in most cases the body was firmer, and there were larger and fewer eyes. He states that this improvement seems to be due to the removal of dirt and cellular elements from the milk.

Hardell (20) reports that in Ohio every factory using pure cultures was clarifying milk for Swiss cheese during the winter of 1926-27. He states that clarification of milk has been an important factor in the improvement of Ohio Swiss cheese. It has resulted in a decrease in the number of eyes, and at the same time it has increased the size of the eyes. The body and texture of the cheese likewise seemed to have been improved. This investigator thinks that the results obtained by the factories substantiate the work of the Bureau of Dairying, United States Deparment of Agriculture, which consistently demonstrated the value of clarifying milk for Swiss cheese manufacture.

As early as 1894, Babcock (2) started experiments to study the influence of cleaning milk with a centrifugal cream separator on the quality of cheese. He reasoned that, because of the offensive character of the material which accumulated on the inside of the separator bowl, the removal of this from the milk would result in an improvement in the flavor and keeping quality of any milk. Nearly 100 cheese were made by students attending the Wisconsin Dairy School from milk cleaned by a separator, the skim milk and cream being mixed as it came from the machine, and "without exception the flavor and keeping quality of the cheese has been improved."

It was also noticed that cleaning the milk in this way either overcame gassy or "pinholey" curds, or greatly minimized the defect. Babcock thought that cleaning milk with a separator would greatly improve the quality of cheese made from tainted milk. He was uncertain whether the improvement was caused by the aeration to which the milk was subjected when it was passing through the separator, or whether it was due to the removal of the slime. In studying this problem, he found that untreated milk caused gassy cheese, while milk which had been cleaned by running it through a separator, and milk which had been cleaned, but to which separator slime had been added, did not result in gassy cheese. This work was done during the winter season, and when it was repeated during the following summer it was found that "there were just as many hinholes in the curds from the cleaned milk as from that not treated." Babcock summarizes by stating that "although cleaning milk with a separator has not accomplished all that we hoped in the treatment of milk for cheese, we feel that it has been of great benefit, as it has, in nearly every case, improved the quality of the cheese, and the improvement has been more marked with tainted milk than with those in good condition. Especially has it been of benefit for long keeping cheese, as such have retained their flavor much better when made from separator cleaned milk."

Fisk and Price (14) report the results of comparisons of cheddar cheese made from unclarified and clarified milk. The work was carried out during 1919 and 1920 under various conditions in different localities. A total of 82 cheese was made. There was a difference in the average score in favor of the clarified milk cheese of 1.282 for flavor, 0.673 for body and texture, and 1.865 in the total score. "The clarified milk cheese had a firmer, more springy feeling, and showed less of a tendency to puff up than the cheese made from unclarified milk." There appeared to be an improvement in the cheese made when either good or poor quality milk was used, and both with and without starter. The authors state that "the clarifier will sometimes overcome the gas in the milk and curd; at other times it will not overcome this gas, but will change it."

In studies on the effect of clarification on the quality of cheese obtained where low quality and where high quality milk was used, Combs, Martin and Hugglar (5) found that the average total score of cheese made from poor quality milk handled under ordinary conditions was 0.79 points lower for the clarified milk cheese than for the unclarified, whereas when poor quality milk was handled under sanitary conditions, the average total score of the clarified milk cheese was 1.59 points higher than that for the unclarified. When high grade milk handled under ordinary conditions was used for cheese, there was a difference of 2.53 points in the average total score in favor of the clarified milk cheese, and when sanitary conditions were used a difference in favor of the clarified milk cheese of 2.83 points in the average total score. When cheese was made under practical conditions, the average score for flavor was 1.0 points higher for the clarified milk cheese than for the unclarified, and the average score for body and texture 1.16 points higher for the clarified milk cheese than for the unclarified. When the cheese was made under extreme sanitary conditions the average score for flavor was 0.58 points higher for the clarified milk cheese than for the unclarified, and the average score for body and texture

1.66 higher for the clarified milk cheese than the unclarified. The authors conclude that although there was a difference of 1.03 in the average total score in the 41 comparisons in favor of clarification, the clarified milk cheese, under present market conditions, would not sell for a higher price; it would therefore be doubtful whether the process of clarification would be justified in the average cheese factory.

The results obtained by the majority of the many research workers who have studied cheese ripening since Duclaux (9) in 1878 first began this type of investigation, seem to point to four outstanding facts: (1) Acid is necessary for the breaking down of the insoluble calcium paracaseinate to monocalcium paracaseinate, which in turn changes to other forms, (2) bacteria are essential in the production of flavor and aroma and in the development of the desirable body and texture of cheese, (3) an enzyme present in rennet effects an increase in the soluble nitrogen compounds in cheese during ripening, thus aiding in producing a more plastic body, and (4) galactase breaks down the calcium paracaseinate to more soluble products. A large amount of research work has been done in various parts of the world on the subject of cheddar cheese ripening, and many theories have been put forth regarding the changes which take place during the curing process.

Evans, Hastings and Hart (13) in 1914 reported the results of a study of the bacteria concerned in the production of the characteristic flavor of cheese of the cheddar type. They summarize their findings by stating that there are four groups of bacteria present in cheddar cheese in such numbers as to indicate that they must function in the ripening process. They are: (1) *Bacterium lactis acidi,* (2) the *B. casei,* (3) *Streptococcus,* and (4) *Micrococcus.* On the basis of the fermentation powers, each of the four groups may be divided into a number of varieties. The flora of raw milk cheese is varied and includes all the varieties into which the four groups may be divided.

The literature on the subject of cheese ripening consists of several hundred references. Hucker (23) has recently made a review of the bacteriological aspects of cheese ripening and summarizes this by the following statement: "As it stands today, the investigations have clearly demonstrated that the breaking down of the insoluble casein compounds is due to enzymes, either natural or bacterial; while characteristic flavors are produced by the action of certain groups of bacteria (*Bact. casei* or coccus group), which depend upon the products of *B. lactis acidi* present in large numbers during the manufacture and early ripening stages."

Later investigational work by Hucker (24) has been done on the types of bacteria present in American cheddar cheese. He studied 265 cultures of bacteria obtained from 37 samples of various grades of commercial cheese. He divides these cultures into seven groups as follows: (1) spore formers, (2) gram-negative rods, (3) lactobacilli, (4) *Streptococcus lactis,* (5) cocci, (6) streptococci other than *S. lactis,* and (7) yeasts. He concludes from his study that in the higher grades of cheese, the *S. lactis* and lactobacilli were the predominating types, while in the lower grades the spore-forming and gram-negative rods were most abundant. There seemed to be little variation in the frequency of the cocci and streptococci (other than *S. lactis*) in the different qualities of cheese.

In a study of the relation of the number of bacteria in milk to the quality of cheddar cheese, Hucker (22) found that the total number of bacteria present in milk used in the making of sixty lots of cheese had no influence upon the quality. The milk which was used varied in bacterial content from 220,000 to 41,400,000 per c.c. when it was received at the cheese factory. Under the conditions of the experiment, the milk that contained from 12 to 42 million bacteria per c.c. produced a cheese of a more constant quality than did the milk containing a smaller number of bacteria. He concludes that the specific types of bacteria present in the milk are far more important than the total number.

Judging from the above brief discussion of the bacteriology of cheddar cheese, it would seem that in order to be effective in the production of a higher quality of cheese, clarification must modify the flora of the milk, and in such a way that the groups of organisms which are responsible for the production of the desirable qualities in cheese predominate during the ripening period.

## METHODS

The milk used in the manufacture of the experimental cheese represents the general milk supply of the Dairy Departments of the Utah Agricultural College and Iowa State College. In general, the milk was of a good quality, but off-flavored milk, and milk having a high bacterial content was occasionally used. Since the cheese was made over a period of several years in the two states, it has been possible to use milk varying as widely in quality as that employed in the various factories.

Approximately twenty gallons of milk were used for each vat, and two cheese were obtained from this amount. Immediately before using, all equipment employed was carefully steamed or rinsed with boiling water. Ten-gallon cans were used for transporting the milk from the milk vat and clarifier to the cheese vats.

In obtaining the clarified milk for the cheese, at least ten gallons of milk were run through the clarifier before the milk for the experimental work was caught.

It was the purpose throughout the trials to employ the usual commercial method of manufacture with little variation. In brief, the method generally used was as follows: One to two per cent of starter was added to the milk as soon as it had been placed in the vats. The milk in each vat was then heated simultaneously to 30°C. (86°F.) and one ounce of color and four ounces of rennet added. Cutting was done with one-quarter inch wire knives. A cooking temperature of 27.8° to 38.9°C. (82° to 102°F.) was used and the acidity at the time of draining was 0.14 to 0.16 per cent. The matting process required two or three hours, and the acidity of the whey at the time of salting was usually about 0.8 per cent or higher. Salt was added at the rate of 2.5 per cent to the curd. The curd was placed in the hoops and pressed at a temperature of 26.7° to 29.4°C. (80° to 85°F.). Usually, pressing occupied 18 to 20 hours. An average curing room temperature of 12.8° to 15.5°C. (55° to 60°F.) was maintained. The cheese were scored when they had been cured about one month and again after about three months. It was the aim to make a firm-bodied cheese having a moisture content of about 36 per cent.

When scoring, the cheese were numbered, so as to give no information to the judges on the kind of milk used for each cheese. For the purpose of making careful comparisons, the make of each day was judged separately.

Representative lots of cheese were examined for numbers and types of bacteria present. In obtaining the samples, the surface of the cheese was cut with a sterile knife, and a sterile trier was then used for securing a plug of cheese. Thin slices were cut from this and weighed on paper. About one gram of cheese was used for an analysis and this was thoroughly ground in a sterile mortar with sterile sea sand. The grinding process occupied at least twenty minutes; when completed, the material was transferred to a water blank and plated on beef infusion agar. The plates were incubated at room temperature for five to six days with the exception of those from the one month old cheese, which were incubated at 37°C. (98.6°F.) for 16 hours and then at room temperature for four days.

## RESULTS

### A. *Scores on Cheese from Unclarified and Clarified Milk.*

Five different series of cheese were made. Series one to four, inclusive, comprise cheese made under normal conditions, while milk containing added slime or alkali forming bacteria was used for the cheese made in series five.

#### *Summary of the Scores of Cheese in Series 1 to 4*

The summary of the results obtained in the 67 comparisons of cheese made from unclarified and clarified milk, presented in table 7, shows that clarification caused increases and decreases in the total scores of the cheese, while in a number of comparisons there was no change. An increase occurred more frequently than a decrease.

In the one month old cheese clarification resulted in an increase in the average score for flavor and aroma of all the cheese of 0.07, while in the three months old cheese it resulted in an increase of 0.41.

In the one month old cheese clarification caused no change in the average score for body and texture of all the cheese while in the three months old cheese it resulted in an increase of 0.15.

When the total scores of the cheese in all the comparisons are considered, clarification caused an increase in the average score of the one month old cheese of 0.07 and in the three months old cheese of 0.56.

#### *Summary of the Scores of Cheese in Series 5*

A. If the clarifier is to improve the quality of milk bacteriologically, it must remove undesirable bacteria from the milk and deposit them in the slime. In order to determine the effect of the addition of the slime obtained from 40 gallons of milk to 20 gallons of clarified milk on the quality of cheese obtained from unclarified milk of the same lot, six trials were made.

The total scores showed that the addition of slime caused in the one month old cheese an average decrease of 1.08, and in the three months old cheese of an average decrease of 1.25.

B. The results obtained in the study of the types of bacteria present in unclarified milk and in the clarifier slime obtained from it, which are shown in Part I, indicate that the alkali forming bacteria are the ones which are measurably removed by the clarifier.

TABLE 7. *Summary of Scores of Cheese, Series 1 to 4.**

| | Flavor and aroma | | | | Body and texture | | | | Average total scores | | | | Flavor and |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | | | | For flavor and aroma, body and texture, color and finish | | | | |
| | Unclarified 1 month | Clarified 1 month | Unclarified 3 months | Clarified 3 months | Unclarified 1 month | Clarified 1 month | Unclarified 3 months | Clarified 3 months | Unclarified 1 month | Clarified 1 month | Unclarified 3 months | Clarified 3 months | 1 month |
| | Av. score | Av. score | Av. score | Av. score | Av. score | Av. score | Av. score | Av. score | | | | | |
| Series 1 | 37.125 | 37.300 | 36.090 | 36.818 | 29.300 | 29.225 | 29.000 | 29.023 | 91.425 | 91.525 | 90.09 | 90.84 | +0.175 |
| Series 2 | 37.950 | 38.300 | 37.900 | 37.950 | 26.900 | 27.300 | 27.300 | 27.700 | 89.850 | 90.600 | 90.200 | 90.650 | +0.350 |
| Series 3 | 39.265 | 39.176 | 39.285 | 39.357 | 27.264 | 27.206 | 27.821 | 27.750 | 91.529 | 91.382 | 92.106 | 92.106 | —0.089 |
| Series 4 | 36.656 | 36.594 | 38.800 | 39.267 | 26.719 | 26.625 | 26.233 | 26.633 | 88.375 | 88.219 | 90.033 | 90.900 | —0.062 |
| Total scores, series 1 | 742.5 | 746.0 | 794.0 | 810.0 | 586.0 | 584.5 | 638.0 | 638.5 | 1828.5 | 1830.5 | 1982.0 | 1998.5 | |
| Number of comparisons | 20 | 20 | 22 | 22 | 20 | 20 | 22 | 22 | 20 | 20 | 22 | 22 | |
| Total scores, series 2 | 379.5 | 383.0 | 379.0 | 379.5 | 269.0 | 273.0 | 273.0 | 277.0 | 898.5 | 906.0 | 902.0 | 906.5 | |
| Number of comparisons | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | 10 | |
| Total scores, series 3 | 667.5 | 666.0 | 550.0 | 551.0 | 463.5 | 462.5 | 389.5 | 388.5 | 1556.0 | 1553.5 | 1289.5 | 1289.5 | |
| Number of comparisons | 17 | 17 | 14 | 14 | 17 | 17 | 14 | 14 | 17 | 17 | 14 | 14 | |
| Total scores, series 4 | 586.5 | 585.5 | 582.0 | 589.0 | 427.5 | 426.0 | 393.5 | 399.5 | 1414.0 | 1411.5 | 1350.0 | 1363.5 | |
| Number of comparisons | 16 | 16 | 15 | 15 | 16 | 16 | 15 | 15 | 16 | 16 | 15 | 15 | |
| Av. of all comparisons | 37.71 | 37.78 | 37.78 | 38.19 | 27.72 | 27.72 | 27.77 | 27.92 | 90.43 | 90.50 | 90.55 | 90.11 | +0.07 |

+ = Increase in score.
— = Decrease in score.

*Cheese scored by Professor E. F. Goss, Dr. N. S. Golding and Mr. H. R. Lochry.

TABLE 7. *Summary of Scores of Cheese, Series 1 to 4.**

| …rified …onths | Average total scores | | | | Changes in average scores due to clarification | | | | | | Times change in total scores due to clarification | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | For flavor and aroma, body and texture, color and finish | | | | Flavor and aroma | | Body and texture | | Total score | | 1 month | | | 3 months | | |
| …score | Unclarified 1 month | Clarified 1 month | Unclarified 3 months | Clarified 3 months | 1 month | 3 months | 1 month | 3 months | 1 month | 3 months | Increase | Decrease | No change | Increase | Decrease | No change |
| …023 | 91.425 | 91.525 | 90.09 | 90.84 | +0.175 | +0.727 | −0.075 | +0.023 | +0.100 | +0.75 | 11 | 8 | 1 | 14 | 5 | 3 |
| …700 | 89.850 | 90.600 | 90.200 | 90.650 | +0.350 | +0.050 | +0.400 | +0.400 | +0.750 | +0.45 | 7 | 3 | 0 | 5 | 5 | 0 |
| …750 | 91.529 | 91.382 | 92.106 | 92.106 | −0.089 | +0.072 | −0.059 | −0.071 | −0.147 | 0.000 | 10 | 5 | 2 | 6 | 5 | 3 |
| …333 | 88.375 | 88.219 | 90.033 | 90.900 | −0.062 | +0.467 | −0.094 | +0.400 | −0.156 | +0.867 | 6 | 4 | 6 | 10 | 3 | 2 |
| …5 | 1825.5 | 1830.5 | 1982.0 | 1998.5 | | | | | | | | | | | | |
| | 20 | 20 | 22 | 22 | | | | | | | | | | | | |
| …) | 898.5 | 906.0 | 902.0 | 906.5 | | | | | | | | | | | | |
| | 10 | 10 | 10 | 10 | | | | | | | | | | | | |
| …5 | 1556.0 | 1553.5 | 1289.5 | 1289.5 | | | | | | | | | | | | |
| | 17 | 17 | 14 | 14 | | | | | | | | | | | | |
| …5 | 1414.0 | 1411.5 | 1350.0 | 1363.5 | | | | | | | | | | | | |
| | 16 | 16 | 15 | 15 | | | | | | | | | | | | |
| …92 | 90.43 | 90.50 | 90.55 | 90.11 | +0.07 | +0.41 | 0.00 | +0.15 | +0.07 | +0.56 | | | | | | |

TABLE 8. *Influence of Clarification on the Numbers and Types of Bacteria Present in Cheese.*

| No. | | One month | | | Three months | | |
|---|---|---|---|---|---|---|---|
| | | Bacteria per gram | Inc. over unclarified in percentage | Inc. in score due to clarification | Bacteria per gram | Inc. over unclarified in percentage | Inc. in score due to clarification |
| 318 | U.* | 1,678,000 | | | 1,100,000 | | |
| 318 | Cl.** | 4,326,500 | 157.8 | —0.5 | 2,951,000 | 168.3 | +0.5 |
| 319 | U. | 3,492,600 | | | 3,268,000 | | |
| 319 | Cl. | 1,781,000 | —49.0 | —5.0 | 6,720,000 | 105.6 | —1.0 |
| 319 | Cl. (no starter) | 36,658,000 | 949.6 | | 10,748,000 | 228.9 | |
| 320 | U. | 17,319,000 | | | 8,450,000 | | |
| 320 | Cl. | 7,207,000 | —58.4 | —3.0 | 10,840,000 | 28.3 | —0.5 |
| 320 | Cl. and slime | 16,380,000 | —5.4 | | 6,806,000 | —19.5 | |
| 322 | U. | 6,920,000 | | | 4,182,000 | | |
| 322 | Cl. | 5,701,000 | —17.7 | —4.0 | 20,770,000 | 396.6 | —1.5 |
| 322 | Cl. and slime | 6,250,000 | 9.7 | | 7,039,000 | 68.3 | |
| 323 | U. | 20,742,000 | | | 12,150,000 | | |
| 323 | Cl. | 2,335,000 | —88.7 | +1.0 | 8,366,000 | —31.1 | +0.5 |
| 323 | Cl. and slime | 2,742,000 | —86.8 | | 7,096,000 | —41.6 | |

TABLE 8. *Continued.*

| No. | | Percentage | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Acid | | | | | | Alkali formers | | Peptonizers | | | | | |
| | | Coagulators | | Non-coagulators | | Inert | | | | Neutral | | Acid | | Alkali | |
| | | 1 mo. | 3 mo. | 1 mo. | 3 mo. | 1 mo. | 3 mo. | 1 mo. | 3 mo. | 1 mo. | 3 mo. | 1 mo. | 3 mo. | 1 mo. | 3 mo. |
| 318 | U.* | 18.0 | 60.0 | 70.0 | 40.0 | 10.0 | | | | | | 2.0 | | | |
| 318 | Cl.** | 8.0 | 66.0 | 84.0 | 32.0 | 8.0 | 2.0 | | | | | | | | |
| 319 | U. | 10.0 | 70.0 | 70.0 | 30.0 | 20.0 | | | | | | | | | |
| 319 | Cl. | 22.0 | 78.0 | 72.0 | 22.0 | 4.0 | | | | | | 2.0 | | | |
| 319 | Cl. (no starter) | 12.0 | 58.0 | 26.0 | 40.0 | 2.0 | | | | | | 60.0 | | | 2.0 |
| 320 | U. | 8.0 | 84.0 | 84.0 | 16.0 | 4.0 | | | | | | 4.0 | | | |
| 320 | Cl. | 6.0 | 90.0 | 90.0 | 10.0 | 4.0 | | | | | | | | | |
| 320 | Cl. and slime | 16.0 | 92.0 | 62.0 | 8.0 | 12.0 | | | | | | 10.0 | | | |
| 322 | U. | 14.0 | 56.0 | 86.0 | 44.0 | | | | | | | | | | |
| 322 | Cl. | 36.8 | 90.0 | 59.2 | 8.0 | | | | | | | 4.0 | 2.0 | | |
| 322 | Cl. and slime | 16.0 | 68.0 | 84.0 | 32.0 | | | | | | | | | | |
| 323 | U. | 82.0 | 90.0 | 18.0 | 6.0 | | 4.0 | | | | | | | | |
| 323 | Cl. | 70.0 | 78.0 | 28.0 | 22.0 | | | | | | | 2.0 | | | |
| 323 | Cl. and slime | 42.0 | 82.0 | 56.0 | 16.0 | 2.0 | 2.0 | | | | | | | | |

*Unclarified.
**Clarified.

A study was made of the effect on the quality of the cheese, of the addition of a pure milk culture of an alkali former to five batches of clarified milk; unclarified milk of the same lot was used for the controls.

The results obtained showed that the addition of one per cent of a milk culture of alkali forming bacteria to clarified milk caused, in general, a small decrease in the scores of the cheese when these are compared with the scores obtained from cheese made from unclarified milk of the same lot.

## B. *Bacteriological Studies*

### 1. *Influence of Clarification of Milk on the Numbers and Types of Bacteria Present in Cheese.*

Five different lots of cheese were examined for the numbers and types of bacteria present and the findings compared with the results obtaind from the scorings.

In one comparison, cheese was made from unclarified and clarified milk of the same lot; in another, from unclarified milk, clarified milk, and clarified milk containing no starter; while in three, unclarified milk, clarified milk, and clarified milk containing added slime were used. Table 8 gives the numbers of bacteria and the percentages of the various types present in the cheese when it was about one month old and also when about three months old.

In one month old cheese clarification caused an increase in the number of bacteria present in one comparison and a decrease in four, while in the three months old cheese clarification caused an increase in the number of bacteria present in four comparisons and a decrease in one.

In the one month old cheese the number of bacteria per gram in the cheese made from unclarified milk ranged from 1,678,000 to 20,742,000, and in the cheese made from clarified milk containing slime they ranged from 2,742,000 to 16,380,000. The one cheese made from clarified milk without starter contained 36,658,000.

In the three months old cheese the number of bacteria per gram of the cheese made from unclarified milk ranged from 1,100,000 to 12,150,000, in the cheese made from clarified milk 2,951,000 to 20,770,000, and in the cheese made from clarified milk containing slime from 6,806,000 to 7,096,000. These great differences in the numbers of organisms present in the cheese made from treated and untreated milk may not be as significant as they would seem. Large errors may result from the difficulty with which bacterial groups and chains present in the cheese are broken up and distributed during the grinding of the sample. Ordinarily, the number of bacteria present in cheese is high. In this study the numbers present were relatively small; probably many of the organisms had died before the cheese was examined. The period of examination would suggest this.

In the one month old cheese the numbers of bacteria in the clarified milk cheese exceeded those present in the unclarified milk cheese from —88.7 to 157.8 per cent. Adding slime to clarified milk caused increases from —86.8 to —5.4 per cent, as compared with the bacteria present in the cheese from unclarified milk, while in the cheese made from milk containing no starter there was an increase of 949.6 per cent.

In the three months old cheese the numbers of bacteria in the clarified milk cheese exceeded those present in the unclarified milk cheese from

—31.1 to 395.6 per cent, adding slime to clarified milk caused increases from —41.6 to 68.3 per cent, as compared with the bacteria present in the cheese from unclarified milk, while in the cheese made from milk containing no starter there was an increase of 228.9 per cent.

In the one month old cheese clarification caused an increase in the total score in one comparison and a decrease in four. In the comparison when there was an increase in the numbers of bacteria there was a decrease in the score. In the comparison where there was the greatest decrease in numbers of bacteria there was an increase in the score. An increase or decrease in the numbers of bacteria did not cause a similar increase or decrease in the total score.

In the three months old cheese clarification caused an increase in the total scores in two comparisons and a decrease in three. An increase or decrease in the numbers of bacteria present did not regularly cause a corresponding increase or decrease in the scores of the cheese.

The results of a study of the effect of clarification of milk and the addition of slime to clarified milk on the types of bacteria present in the cheese show that in both the one month and three months old cheese, with the exception of that made from clarified milk containing no starter, the acid forming groups constituted the majority of the organisms present; these groups were always present in the cheese made from unclarified milk, clarified milk, and clarified milk containing added slime; sometimes there was an increase and sometimes a decrease in these groups as a result of treating the milk. The alkali formers and neutral peptonizers were entirely absent. In some of the comparisons the one month old and the three months old cheese contained small numbers of inert and acid peptonizers. The one month old cheese made from clarified milk containing no starter contained a large percentage of acid peptonizers, while the three months old cheese showed a flora which was similar to that of the cheese made from the unclarified and clarified milk of the same lot.

In summarizing these results, it would appear that clarification of milk and the addition of slime to clarified milk had no specific influence on the numbers and types of bacteria present in the cheese, and that an increase or decrease in the numbers of bacteria present in the cheese obtained from the treated milk as compared with the numbers present in the cheese from the untreated milk of the same lot did not result in a corresponding constant increase or decrease in the total scores of the cheese.

### 2. *Relation Between the Numbers of Bacteria Present in Unclarified and Clarified Milk and the Quality of Cheese Obtained.*

In order to determine the relation between the numbers of bacteria present in the unclarified and clarified milk used and the quality of the cheese made, 28 comparisons were made. The cheese were made during the period May to July, 1927, inclusive.

Table 9 shows the plate counts of the milk used, the percentage change in numbers due to clarification, and the increase in the total scores of the cheese caused by clarification. The counts of the unclarified milk ranged from 20,900 to 15,010,000 per c.c. Clarification caused an increase in the bacterial count in three trials and a decrease in 25. The increases in the counts varied from 5.0 to 23.8 per cent and averaged 11.8 per cent, while

TABLE 9. *Relation Between Numbers of Bacteria Present in Unclarified and Clarified Milk and the Quality of Cheese Obtained.*

| Number | Unclarified | Clarified | Percentage | | Increase in total score due to clarification | |
|---|---|---|---|---|---|---|
| | | | Increase | Decrease | 1 month | 3 months |
| 512 | 20,900 | 19,800 | | 5.3 | 1.0 | —0.5 |
| 513 | 530,000 | 485,000 | | 8.5 | 0.5 | 0.0 |
| 514 | 350,000 | 250,000 | | 28.6 | —1.0 | 0.5 |
| 516 | 710,000 | 530,000 | | 25.4 | 0.5 | 0.0 |
| 521 | 11,470,000 | 9,480,000 | | 17.4 | 2.0 | 0.5 |
| 523 | 11,400,000 | 9,160,000 | | 19.7 | 1.5 | —0.5 |
| 528 | 1,160,000 | 880,000 | | 24.1 | 0.5 | 0.0 |
| 606 | 200,000 | 210,000 | 5.0 | | 1.0 | 1.0 |
| 607 | 63,000 | 78,000 | 23.8 | | 2.0 | — |
| 608 | 1,080,000 | 590,000 | | 45.4 | 0.0 | — |
| 609 | 1,220,000 | 745,000 | | 38.9 | 0.0 | 1.0 |
| 611 | 1,810,000 | 1,360,000 | | 24.3 | 1.0 | — |
| 613 | 490,000 | 360,000 | | 26.5 | 0.0 | 4.0 |
| 614 | 260,000 | 190,000 | | 26.9 | 0.0 | 1.0 |
| 615 | 137,000 | 119,000 | | 13.1 | 0.5 | 1.0 |
| 616 | 114,000 | 107,000 | | 6.1 | 0.0 | —1.0 |
| 617 | 3,290,000 | 2,630,000 | | 20.1 | 0.0 | 0.0 |
| 620 | 2,480,000 | 2,340,000 | | 5.6 | 0.0 | —0.5 |
| 621 | 15,010,000 | 7,620,000 | | 49.2 | —3.0 | 0.5 |
| 622 | 560,000 | 400,000 | | 28.6 | —2.5 | —2.0 |
| 623 | 8,180,000 | 5,340,000 | | 34.7 | —1.5 | 0.0 |
| 624 | 4,200,000 | 2,000,000 | | 52.4 | 0.0 | 0.5 |
| 627 | 1,490,000 | 820,000 | | 45.0 | 2.0 | 4.0 |
| 628 | 2,210,000 | 1,635,000 | | 26.0 | 0.5 | 3.0 |
| 629 | 1,960,000 | 2,090,000 | 6.6 | | 1.0 | 1.0 |
| 630 | 1,170,000 | 980,000 | | 16.2 | 0.5 | 0.5 |
| 701 | 875,000 | 410,000 | | 53.1 | 0.5 | 1.0 |
| 705 | 11,800,000 | 10,600,000 | | 10.2 | — | — |

the decreases varied from 5.3 to 53.1 per cent and averaged 26.1 per cent. Considering the 28 comparisons, there was an average decrease of 22.0 per cent as a result of clarification. The results are comparable with those obtained in Part I, where clarification caused increases and decreases in the counts, a decrease being caused more often when the number of bacteria per c.c. exceeded 100,000.

With the smallest increase in bacterial count, as a result of clarification, there was an increase in the total score of the one month old cheese of 1.0, and an increase in the total score of the three months old cheese of 1.0. With the largest increase in the count, there was an increase in the total score of the one month old cheese of 2.0. The three months old cheese in this comparison was not scored.

With the smallest decrease in the bacterial count, as a result of clarification, there was an increase in the total score of the one month old cheese of 1.0, and a decrease in the total score of the three months old cheese of 0.5. With the largest decrease in the count, there was an increase in the total score of the one month old cheese of 0.5 and an increase in the total score of the three months old cheese of 1.0.

When all the comparisons are considered, there was an average increase in the total score of the one month old cheese of 0.23 and an increase in the total score of the three months old cheese of 0.60.

Comparisons Nos. 613, 627 and 628 show the largest increase in the total score of the cheese and clarification caused a decrease in numbers of bacteria in the milk used of 26.5, 45.0, and 26.0 per cent, respectively. Comparisons Nos. 621 and 622 show the largest decreases in the total score of the cheese and in these clarification caused a decrease in the numbers of bacteria in the milk used of 49.2 and 28.6 per cent, respectively.

These results show that increases or decreases in the numbers of bacteria present in the milk as a result of clarification did not have definite effects on the score of the cheese.

## SUMMARY

### PART I

1. Forty-three comparisons of the effect of clarification on the numbers of bacteria in milk showed that clarification caused an increase in the counts in 20 trials and a decrease in 23 trials. The increases in the counts varied from 3.1 to 143.7 per cent and averaged 54.6 per cent, while the decreases varied from 0.4 to 59.1 per cent and averaged 24.9 per cent. Considering the 43 comparisons, clarification caused an average increase of 12.1 per cent. With the milk studied, clarification more often caused a decrease in the count in the milk containing over 100,000 bacteria per c.c. than when the number was smaller.

2. Nineteen comparisons of the influence of clarification on the number of bacteria in milk, using a normal and a reduced rate of inflow, showed that with a normal rate of inflow clarification caused an increase in the counts in six trials and a decrease in 13, but when the rate of inflow was reduced, clarification always caused a decrease. With the normal rate of inflow the increases varied from 5.9 to 64.8 per cent and averaged 35.1 per cent, while the decreases varied from 3.4 to 60.2 per cent and averaged 20.8 per cent. Considering the 19 comparisons, there was an average decrease of 3.1 per cent. When the rate of inflow was reduced there was a minimum decrease of 25.9 per cent, a maximum of 80.5 and an average of 55.3 per cent.

3. Twenty-one comparisons of the influence of clarification on the types of bacteria present in milk showed that clarification had an irregular effect on the bacterial flora. Sometimes it caused an increase and sometimes a decrease in each of the groups of organisms present in the milk. The increases in the acid coagulators varied from 0.3 to 34.3 per cent and the decreases from 0.2 to 23.7 per cent, with an average increase, when all the comparisons are considered, of 3.4 per cent. The acid non-coagulators showed increases varying from 0.8 to 24.0 per cent, decreases from 0.8 to 16.0 per cent, and an average increase in all comparisons of 3.9 per cent. The alkali formers were increased from 0.1 to 16.0 per cent and decreased from 1.2 to 22.0 per cent, with an average decrease for all comparisons of 1.8 per cent. The other groups showed similar increases and decreases.

4. Thirty-three comparisons of the types of bacteria present in unclarified milk and in the slime obtained from it showed that the only groups which indicated a fairly consistent change as a result of clarification were the acid coagulators and the alkali formers. The average changes were an 8.7 per cent decrease in the percentage of acid formers and a 16.8 per cent

increase in the percentage of alkali formers in the slime as compared with the milk.

5. The results of a series of 18 comparisons on the effect of clarification with a normal and a reduced rate of inflow on the types of bacteria in milk showed that clarification with both methods caused little change in the types of bacteria present. The variations were not consistent or large enough to permit of any conclusions other than that the clarifier had no pronounced selective action on the types of bacteria present in the milk under either method of clarification.

6. In nine comparisons clarification under a normal and under a reduced rate of inflow caused an increase in the time required to reduce methylene blue, when unclarified milk was used as the basis for comparison. The average increases in the reduction time when all the comparisons are considered were 21 minutes with a normal rate of inflow and 47 minutes with clarification under a reduced rate of inflow. The results agreed, in general, with those obtained by the plate method, but the latter method was more refined in showing the changes in the numbers of bacteria of milk resulting from clarification. Observations of the fermentation test indicated that clarification with both rates of inflow had little effect on the fermentation occurring.

7. When raw milk was subjected to centrifugal force in centrifuge tubes for various periods of time, it was found in four comparisons that five minutes centrifuging removed an average of 12.6 per cent of the bacteria present, while 20 minutes exposure to the centrifugal force removed an average of 16.7 per cent in the sediment. The centrifuging of samples of milk of the same lot for five, ten and thirty minutes, respectively, in four comparisons, and for five and twenty minutes in four other comparisons caused only slight changes in the bacterial flora; whenever a certain type of organism was present in the milk it was also found in the sediment. Even an exposure of the milk to centrifugal force for 30 minutes did not cause a complete elimination of any of the types of bacteria present in the milk. By subjecting raw milk to centrifugal force in tubes, it was possible to remove a large percentage of alkali forming organisms or yeasts which had been inoculated into it from agar slopes.

8. The specific gravity of *Torula cremoris,* when grown on agar, was found in four determinations to vary from 1.037 to 1.102, with an average of 1.079. Various cultures of alkali forming bacteria grown on agar were found in 13 determinations to have specific gravities ranging from 1.029 to 1.123 and averaging 1.0497, while when bouillon was the medium, the specific gravities in two determinations were 1.025 and 1.032, with an average of 1.0285.

9. A morphological, cultural and biochemical study of 31 cultures of alkali forming bacteria showed that the differences exhibited were too small to permit a division into varieties of the species to which they belong.

## PART II

1. The study of the influence of clarification on the quality of cheese made from 67 different lots of milk showed that in the one month old cheese clarification resulted in an increase of 0.07 in the average score for flavor and aroma of all the cheese, while it resulted in an increase of 0.41 in the

three months old cheese. In the one month old cheese clarification caused no change in the average score for body and texture of all the cheese, while in the three months old cheese it resulted in an increase of 0.15. When the total scores of the cheese in all the comparisons are considered, clarification caused an increase of 0.07 in the average score of the one month old cheese and an increase of 0.56 in the three months old cheese.

2. In six comparisons the addition of clarifier slime to clarified milk caused, on an average, a decrease in the quality of the cheese. In the one month old cheese it caused an average decrease of 1.08 in the total score, and in the three months old cheese an average decrease of 1.25.

In five comparisons the addition of a pure culture of alkali forming bacteria to clarified milk caused an average decrease of 1.20 in the total scores of the one month old cheese, and an average decrease of 0.40 in the three months old cheese.

3. Clarification of milk and the addition of slime to clarified milk did not have any specific influence on the numbers and types of bacteria present in the resultant cheese. An increase or decrease in the numbers of bacteria in the cheese obtained from the treated milk as compared with the numbers present in the cheese from the untreated milk of the same lot did not result in a corresponding increase or decrease in the total scores of the cheese.

4. Clarification caused increases and decreases in the numbers of bacteria present in milk, but corresponding increases or decreases in the scores of the cheese did not regularly follow these.

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# EXPERIMENTS ON THE PHYSIOLOGICAL RELATIONSHIPS BETWEEN THE STOMACH INFUSORIA OF RUMINANTS AND THEIR HOSTS, WITH A BIBLIOGRAPHY

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The general problem of host-parasite relationships has captivated present day workers in protozoology. One of the most outstanding pieces of work in this field was that by Cleveland (1924), which has apparently demonstrated that certain termites are dependent upon the protozoan fauna of their digestive tract for the digestion of the cellulose in their woody diet. These protozoa are thus true symbionts. The zoologist is naturally curious to know whether or not other mutually beneficial associations between entozoic protozoa and their metazoan hosts occur in nature. After Cleveland's paper was published, the question was frequently asked, "Do the infusoria in the paunch of a ruminant assist their host in a similar manner?" We find that the same inquiring frame of mind held Gruby and Delafond, who in 1843 discovered the protozoan fauna of the rumen and reticulum of domestic ruminants (also that of the caecum and colon of the horse) during their investigations on digestion. Their opinions will be presented later, but the point we wish to emphasize here is that they, and most of the investigators since them who have studied this stomach fauna characteristic of ruminants, have ventured either to express an opinion concerning the physiological rôle of these organisms in their host or to mention the statements of others regarding them.

We find after a thorough review of the literature that various views have been held regarding the value of the rumen infusoria to their host. These views may be stated briefly as follows: (1) The rumen infusoria convert substances in plant food into the more easily digestible animal substance of their own bodies, which in turn are sacrificed to the action of the digestive juices of their host; (2) they are harmful parasites; (3) they are harmless commensals; (4) they check the increase of Schizomycetes which would eventually become harmful to their host; (5) they assist in the digestion of cellulose; (6) they are valuable to their host in mechanical ways; namely, the thorough mixing and trituration of the rumen contents. Each topic will be discussed separately in the following paragraphs.

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1. *Conversion of Plant Substances Into Animal Substances.*

Gruby and Delafond (1843) felt that the presence of such vast numbers of microörganisms in the stomach of an animal during the digestion of food indicated that they held a certain importance in the digestive processes of their host. This thought would naturally occur to them, for they were working on the general problem of digestion in domestic animals; and the important discovery of the existence of these most complex protozoa was merely incidental to their principal objective. They observed that the protozoa occupied only the rumen and reticulum of the stomach, and that those which were carried with the food mass into the true stomach were digested there. They reasoned in an empirical way: the ruminant is a herbivorous animal; these protozoa grow upon plant nutrients, which are converted into animal protoplasm; this in turn is digested by the ruminant, making it in a certain sense carnivorous.

This general theory takes more definite and modern form in the recent work of Schwarz (1925). To him the protozoa play the rôle of converting amides and protein derivatives, difficult to digest, into easily digestible animal protoplasm. He writes, "Es erscheint daher nicht ausgeschlossen, dass diese Mikroorganismen, wie bereits früher von den oben gennanten Autoren für möglich gehalten wurde, eine bedeutsame Nahrungsquelle für die Wiederkäuer darstellen, wodurch zum Beispiel die in den Pflanzen vorkommenden Amide und die tiefen, durch Bakterientätigkeit erhaltenen Eiweiss Spaltprodukte in einer wieder verwertbaren Form als Infusorienprotoplasma gestapelt werden." He finds upon chemical analysis that 20 per cent of the nitrogen in the rumen contents is stored up in the infusoria and about 11.7 per cent in the bacteria. After certain calculations upon the protein requirements of ruminants, he concludes that the microörganisms in the anterior portion of the stomach of ruminants have a relatively large, if not predominant, importance as sources of nourishment. In a later paper Schwarz and Bienert (1926) expressed a similar view of the situation regarding the infusoria in the caecum of the horse.

Biedermann (1911) says that the infusoria are of no important use as protein converters. Scheunert (1924) believes that they are not present in sufficient amounts to be of any great importance. Mangold and Schmitt-Krahmer (1927), employing the method of analyzing rumen contents of sheep comparatively infusoria-free and normal sheep, find nothing like the 20 per cent increase in N content of the latter over the former, as would be expected from the results of Schwarz. The most recent work on this subject is by Ferber (1928), whose results lead him to believe that the infusoria may have some rôle in converting the proteins in the plant food into more easily digestible infusorian protoplasm, but that they cannot convert amides into proteins, as reported by Schwarz. Later, Ferber and Winogradowa-Fedorowa (1929) state: "Diese Tatsache sheint uns, neben den obenerwähnten, dafür zu sprechen und zu bestätigen, dass den Panseninfusorien eine wichtige physiologische Bedeutung und eine notwendige Rolle für die Ernährung ihrer Wirtstiere zukommt." Buisson (1923) suggests that they supply an animal element in the ration of herbivorous animals.

Later we present some of our results bearing upon the foregoing problem, although it is by no means settled.

2. *Injurious Parasites.*

So far as we can learn, the view that the stomach infusoria are injurious to their host has been held only by Zürn (1887). He thought that they could lead to the development of pathological conditions in the alimentary track (*Magen- und Darmkatarrh*). Subsequent investigators have learned that his opinion was incorrect, for the occurrence of these protozoa in almost every normal healthy ruminant seems to imply a well-being of the host, rather than a diseased condition (Cf. Trier, 1926, p. 307). (This is probably because sick animals eat little or no food, and under these conditions the numbers of infusoria decrease very rapidly.)

3. *Harmless Commensals.*

Bundle (1895), Biedermann (1911), Scheunert (1924), Scheunert and Schielblich (1927) take the position that these protozoa are harmless commensals. If they are of any value to their host, it is in mechanical ways. Likewise, Weiss (1869) presumably held the commensal idea, for he opposed Gruby and Delafond's idea that they were of value in the digestive processes.

4. *Reduction of Schizomycetes.*

The idea that the rumen infusoria might be useful as scavengers was original with List (1885). The ingestion by the infusoria of bacteria and moulds on a large scale would serve to prevent their inordinate multiplication, which would eventually become dangerous to the animal organism.

Why does not the rumen content of an ox, with its twenty or thirty gallons of water, saliva, hay and grain, at a favorable temperature for bacterial growth, and teeming with bacteria, become a putrefying mass? This, as yet, has not been explained fully.

5. *Digestion of Cellulose.*

It has long been known that ruminants digest a considerable amount of the cellulose in their diet of hay, grasses and grains. Schuberg (1888) observed that Entodinium and Diplodinium ingest plant particles, some of them so large as to distort the outline of the cell. He concludes, "dass die Ciliaten speziell für die Celluloseverdauung von Bedeutung sein könnten." Eberlein (1895) noted the ingestion of plant fibre by certain of the rumen infusoria, and its subsequent disintegration within them. He concluded, as others have done since, that these infusoria could digest cellulose. In large numbers they transform a part of the cellulose into a digestible substance. The protozoa are ultimately digested in the stomach and intestine, raising the metabolism of their host. Previously, Certes (1889) had made the more sweeping statement that the protozoa condition the fermentative processes in the rumen. This writer also observed that glycogen from carbohydrate digestion was stored up in the protoplasm of certain of these unicellular organisms.

Liebetanz (1910) is in almost complete accord with Eberlein. Braune (1913) expresses his agreement with the views of Eberlein and Schuberg regarding cellulose digestion.

Reichenow (1927, p. 377), in the new edition of Doflein, immediately after the discussion of the physiological importance of termite protozoa in the digestion of cellulose, states: "Eine ähnliche ernährungsphysiologische Rolle spielen offenbar die Ciliaten aus der Familie der Ophryoscoleciden, die in ungeheuren Mengen in den Verdauungsorganen von Säugetieren mit besonders cellulosereicher Kost vorkommen." He also discusss the importance of the bacteria in cellulose digestion in ruminants.

Cleveland (1924, p. 220), in his classic work proving the importance of the intestinal protozoa of termites in cellulose digestion within their host, wrote: "Intestinal bacteria and fungi quite often aid their vertebrate and invertebrate hosts in the digestion of cellulose and, since it has been shown in the present investigation that intestinal protozoa can digest cellulose, it is now possible that the infusoria, such as *Diplodinium, Entodinium, Buetschlia, Isotricha, Dasytricha,* and *Ophryoscolex,* harbored by ruminants, notably the ox, goat, sheep, camel and reindeer, may aid their hosts in the digestion of cellulose and hemicellulose."

A number of other scientific authorities could be quoted as evidence that the infusoria of ruminants have been seriously considered as valuable aids to their hosts in the digestion of cellulose, although the activity of bacteria in the same direction is not denied. One of our late prominent authors (Slosson, 1928), who was noted for his ability to present scientific work to a popular audience, wrote: "Even the goat that pastures on billboards and the ox that eats straw have to depend upon minute forms of *animal* (italics ours) or plant life that inhabit the digestive tract."

Trier (1926, p. 308) makes the suggestion that there may be bacteria which live in symbiosis with the protozoa and assist the unicellular organism in the digestion of cellulose. He writes: "So wäre es denkbar, dass hier eine direkte Symbiose vorliegt und zellulosebakterien und Infusorien voneinander abhängig sein. Wie weit sich die beiden Vertreter der Kleinlebewelt von pflanzlichen Teilen nähren und ob dabei eine gegenseitige Unterstützung stattfindet, bedarf noch der Klarung. Wenn hier eine zwingende Symbiose nachgewiesen würde, wäre der Beweis erbracht, dass die Infusorien die bakteriellen Gärungsvorgänge unterstützen und so dem Wiederkäuer indirekt von Nutzen sind."

We find, however, that there is no general agreement that the infusoria do assist in cellulose digestion. Bundle (1895) states if they are of any value in this way, it is not appreciable. Biedermann (1911), Scheunert (1924), and Scheunert and Schieblich (1927) are inclined to the view that since a usefulness to their host has not yet been proved, they must still regard these protozoa as commensals, except for some minor mechanical services which they might render their host. It seems to us highly desirable that it be definitely determined whether or not intracellular digestion of cellulose actually takes place in the rumen infusoria. Some of the previously mentioned early workers, as well as the more recent ones, notably Schulze (1924, 1927) and Trier (1928), claim to have seen plant fibers of a cellulose nature reduced to a fine detritus in the endoplasm. The detritus was later expelled from the anus. Dogiel and Fedorowa (1925, pp. 106-107) deny that any disintegration of cellulose elements takes place inside the infusoria. They assert that such particles are expelled from the cell in the same condition as when they were ingested. When this phase of the problem is restudied, appropriate tests should be used to determine definitely that the elements reduced are true cellulose. It is possible that certain plant elements undergo disintegration, while others do not.

6. *Mechanical Services.*

It appears to Bundle (1895), Scheunert (1924), and Scheunert and Schieblich (1927) that the only service which these microörganisms render their host is purely mechanical assistance in soaking (*Quellung*), maceration (*Mazeration*) and thorough mixing (*Durchmischung*) of rumen contents. They do not venture to suggest what would happen if the protozoa were absent.

We have thus summarized the views that have been held by workers in the fields of protozoology, physiology, and veterinary medicine regarding the rôle played by rumen infusoria. Not so much attention has been paid to flagellates and amoebae, for they ingest comparatively small, if any, amounts of cellulose; and most of them are representatives of types widely distributed in nature, rather than members of the peculiarly characteristic rumen infusoria. (Scheunert, 1924, states that members of the genera Buetschlia, Isotricha, and Diplodinium may be found also in the esophageal portion of the stomach of the hamster.) At any rate, it is but natural to ascribe some importance to microörganisms which live, move, and multiply in enormous numbers in a portion of the digestive tract where the important processes of digestion of cellulose and other carbyhydrates, and possibly also portein and vitamin B (*Vide* Bechdel *et alii*, 1928) synthesis, take place. If the infusoria bear any relationship to these processes, economic aspects of the problems are quite evident. It has been our purpose to conduct an investigation of the general problem which would throw as much light as possible upon each of the six hypotheses previously advanced by other workers.

## RATIONALE AND TECHNIQUE OF THE EXPERIMENTS

The experiments were planned so that we might gain the information sought by comparing the results obtained in animals, for a period during which they carried the normal infection of infusoria, with a period during which they were free of the infusoria, both periods being as nearly identical as possible in respect to other conditions. The infusoria-free trials were made first, however, because we feared that otherwise the effcts of the rather rigorous process of defaunation might introduce certain conditions which would complicate the results. In the digestion trials, the digestibility coefficients of protein, ether extract, nitrogen-free extract, crude fiber, hemicellulose, pentosans, alpha cellulose, and total dry matter were determined for both the infusoria-free period, and the one during which the animals carried the infection, hereafter designated the infected period. The partition of nitrogen between feces and urine, as well as the amounts of nitrogen stored daily, were also calculated for both periods.

The goat was chosen in preference to other ruminants because it is said to lend itself to laboratory conditions better than either the ox or sheep. It was decided to use two young and two adult goats for our digestion trials. We were unable to learn the exact ages of the animals, but Goats 1 and 2 were considerably under a year of age, while Goats 3 and 4 were from three to five years. These animals remained healthy throughout the experiment, and at no time was there a refusal of food, making supplementary analysis necessary. They were kept in a large steam-heated room with a cement floor. By properly disposing of excrement and flushing the floor with a hose the room was kept sufficiently sanitary so that it gave little offense to people working in the same building.

Procuring animals infected with infusoria presented no difficulty, because, as is well known, virtually every ruminant is infected with at least some species of the genera Entodinium, Diplodinium, Ophryoscolex, Isotricha, Dasytricha, or Buetschlia. The problem of accomplishing a complete removal of infusoria from the rumen and reticulum was solved by two techniques, which have been discussed elsewhere (Becker, 1929). Two of our animals were defaunated by a method similar to that employed by Liebetanz (1910). His technic may be described briefly as follows: first, the animal was starved three days; at the end of this period a trocar was inserted through the body wall into the rumen; then the final defaunation was accomplished by introducing into the rumen a certain amount of dilute acetic acid, both the amount and the dilution having been previously experimentally determined. We employed his technique with modifications as follows: first, the goat was starved for three days, except that water was given *ad libitum*; then a trocar was inserted into the paunch through the body wall just back of the last rib, as shown in figure 1; immediately 300 c.c. of five per cent acetic acid for half grown goats, or 500 to 600 c.c. for adults, was poured into the rumen through the cannula of the trocar. The following day a mixture consisting of six eggs and a quart of milk was injected into the rumen. The putrefaction of the eggs presumably assisted the acid in killing the protozoa. As soon as the animal would eat, it was given grain and hay. By this method we succeeded in effecting a complete removal of the infusoria in the two half-grown goats; but, like Liebetanz, we were unsuccessful in the case of adult goats, even though the acetic acid dosage was repeated on successive days. The acid sometimes caused reflex vomiting, and when this happened the goat usually died soon afterwards, perhaps from a mechanical pneumonia caused by getting the acid into the lungs. We lost several goats in this way. This method of defaunation is too rigorous and dangerous for ordinary work, although occasionally it may be used successfully. The locations of the various compartments of the goat stomach are shown in figure 1. For information concerning the physiology of the ruminant stomach we consulted Schalk and Amadon (1928).

We tried varying amounts of a ten per cent solution of thymol in chloroform introduced into the rumen through the cannula, but we were not successful in killing all the protozoa in one adult goat. Finally, 6 c.c. of this solution was administered. A few minutes later the animal was found dead, but some of the infusoria were still alive.

The use of $CuSO_4$ as an infusoriacidal agent was found to be not only more effective than the other substances tried, but it also produced less deleterious effects upon the goat. The method is as follows: first, the animal was not permitted to eat for 72 hours, but water was constantly kept before it; then 50 c.c. of two per cent $CuSO_4$ (freshly made) in a pint of distilled water was introduced into the rumen through a rubber tube down the esophagus; another day passed during which the goat was still unfed; then followed another administration of $CuSO_4$ solution, like the first. Several hours later feed was offered. Microscopic examination of rumen samples was made daily for at least two or three weeks to check up on the effectiveness of the treatment. Once removed, the infusoria did not return if feed thoroughly dried and water taken directly from the tap were given (Cf. Becker and Hsiung, 1929).

After completion of the defaunation process, there followed a period of reconditioning the animal of about three weeks duration. During this period it received the same kind of hay and grain mixture that was to be used during the digestion trials. By carefully weighing the food materials a close estimate was made of how much the animal would consume each day and still maintain a keen appetite.

Next, the goat was put into a metabolism crate (described below) for seven days, and given daily the determined amount of alfalfa hay and grain

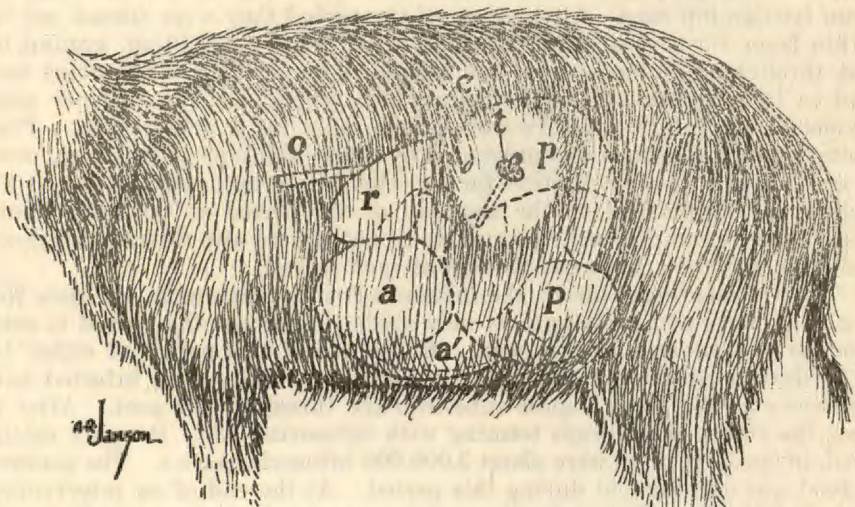



**Figure 1.** Goat stomach with cannula of trocar (*t*) in the upper compartment of the rumen (*P*). *c*, last rib; *O*, esophagus; *r*, reticulum; *a*, abomasum or true stomach.

mixture. Water was given *ad libitum.* The animal was fed half its daily ration of hay at 9 a. m. and the other half at 4 p. m. The grain was fed at noon. This preliminary week of feeding was to thoroughly adjust the goat to its diet. It should be mentioned at this point that the alfalfa hay had been previously chopped into inch lengths by means of an alfalfa chopper, thoroughly mixed and weighed into paper sacks in 1000 gram amounts. Some evaporation of moisture took place, of course, but each sack of hay was weighed just before feeding and evaporation was allowed for. If, for example, a goat was to get 400 grams of chopped hay per feeding, and it was discovered that there had been a moisture loss of 100 grams from the sack, the animal was given four-tenths of the remaining 900 grams of hay. Thus the amounts of the solid content of the hay fed were kept comparable throughout each experiment, regardless of moisture changes.

The grain mixture was likewise thoroughly mixed in a mechanical mixer and weighed out into paper sacks before the experiment was begun.

The grain mixture received by Goat 1 consisted of 50 parts ground oats, 50 parts cracked corn, 20 parts wheat bran, and 20 parts of a popular brand of calf meal. Salt was given *ad libitum*. Goats 2, 3 and 4 received a mixture of 100 parts ground oats, 100 parts cracked corn, 50 parts wheat bran, 10 parts linseed oil meal, 3 parts bone meal, 3 parts limestone, and 1½ parts common salt.

After a week of adjusting itself to its daily rations, the animal was ready for its digestion trials. These were 14 days each for the infusoria-free and the infected periods in the case of two goats, and 21 days each in the case of the other two. The feces and urine were carefully collected daily. The fecal pellets were dried over a hot water bath and stored in large friction-top cans. At the close of the period they were spread out in a thin layer for several days, weighed in an air dry condition, ground to pass through an 80 mesh sieve, and aliquoted for analysis. The urine was kept in large five-gallon bottles, into which several c.c. of a 10 per cent thymol in chloroform mixture were added daily for a preservative. Precipitation of phosphates was prevented by daily additions of small amounts of acetic acid. If the collection for a period began on a certain day at 11 o'clock, it was finished on the last day of the period at the same hour. The composite samples of urine and wash water were also filtered, weighed, and aliquoted for analysis at the end of each period.

As was mentioned above, the infusoria-free period was in all cases the first one. Frequent examinations were made throughout the period to confirm the total absence of infusoria. At the end of this period of either 14 or 21 days, a considerable quantity of rumen contents of an infected animal was expelled from a glass tube into the throat of the goat. After a week the rumen was always teeming with infusorian life. Roughly calculated, in one goat there were about 2,000,000 infusoria per c.c. The amount of food was not changed during this period. At the end of an intervening period of ten days, daily collections of feces and urine were again initiated and carried on throughout the infected period.

The metabolism crates in which the goats were kept during the digestion trials were designed with four purposes in mind; maximum comfort for the goat, elimination of any loss of feed in the process of feeding, collection of all the feces, and collection of the urine separate from the feces and without loss. The general construction is shown in figures 2 and 3, but certain special points will be mentioned. The crate was made sufficiently large so that it permitted the animal to turn around in it: height, 30 inches; length, 48 inches; width, 21 inches. It will be noted (fig. 2) that the stanchion through which the goat thrust its head in order to eat from the feed box was somewhat V-shaped. The head could enter at the top, but could not be withdrawn at the bottom. This prevented the animal from scattering feed within his crate and mixing it with its own excrement. The floor under the crate was of cement so that any particles of hay or grain which fell from the feed-box might be readily swept up and refed.

The collection of the feces unmixed with urine was accomplished by the use of screens. The floor of the crate was of ½ inch mesh hardware cloth, through the openings of which the pellets passed as they dropped down onto a copper screen covering a galvanized iron tray to be described presently (fig. 3). From this screen they were scraped with a large piece of tin into evaporating pans. Pellets which failed to pass through the hardware cloth were picked up. The sides of the crate part way up from the bottom, as shown in the figure, were covered with tin to prevent pellets dropping to the floor. Any which fell onto the cement floor despite these precautions were swept up and saved.

Urine collection was effected by means of a galvanized iron tray beneath the entire floor of the crate. It was supported by cross-pieces between the legs of the crate, and could be withdrawn at one end. The lid of this tray was composed of copper screen framed in galvanized iron, which was bent so that it fit down over the edges of the tray itself. The screen caught the fecal pellets, but permitted the urine to pass through. The upper edge of the tray supporting the lid was horizontal, but the tray was so constructed that it was ½ inch deep at one end and 2¼ in. at the other. This made an incline down which the liquid flowed toward one end. Here was a small spout leading from the bottom. An enamel pan beneath held the urine which passed through this spout. Just after the daily collection of feces and urine, the screen and tray were carefully washed down with distilled water from a sprinkling can, and the wash water was preserved with the urine.

The foregoing account of our methods shows certain points which we wish to emphasize. Each goat, except No. 1, received a uniform ration of hay and grain during both periods. These feeds were each thoroughly mixed, weighed out, and sacked beforehand; and the same amounts were fed daily during the two periods of equal length. Daily collections were made of feces and urine, and these materials were treated so as to reduce changes from bacterial action to a minimum. Later the fecal pellets were ground into a fine powder, and those for each period were thoroughly mixed. The urine was all put into one large glass bottle and thoroughly mixed. Samples of hay and grain mixture for chemical analysis were obtained by saving a handful now and then at the time they were weighed out. Both the hay and grain thus saved were thoroughly mixed and weighed. In this manner aliquot samples thoroughly representative of both hay and grain were obtained for chemical analyses. Also, it should be stressed that comparisons were not made between different goats, but the results secured in different trials with the same animals were compared.

As stated in the foregoing paragraphs, we used trial periods of 14 days each in the case of two of the animals and of 21 days in the case of the other two. These intervals are somewhat longer than the minimum usually considered to be sufficient in digestion trials of this nature. Our information relative to the length of trials was gathered from the recommendations of Forbes and Grindley (1923) for the sub-committee on animal nutrition of the National Research Council, the observations of Schneider and Ellenberger (1927), and previous experience. It has previously been shown that it is impracticable to attempt to mark goat feces by the feeding of charcoal or carmine, so no attempt was made to mark them in this experiment.

FIGURE 2.

**Structure of anterior end of metabolism crate. Stanchion can be closed, to hold goat's head for obtaining sample of rumen contents, by shifting bar *c* from hole *a* to hole *b* and bolting, the bar pivoting on bolt *h*.**

FIGURE 3.

**Showing construction of metabolism crate. Coarse mesh is hardware cloth of ½ inch mesh. Fine mesh is copper srceen.**

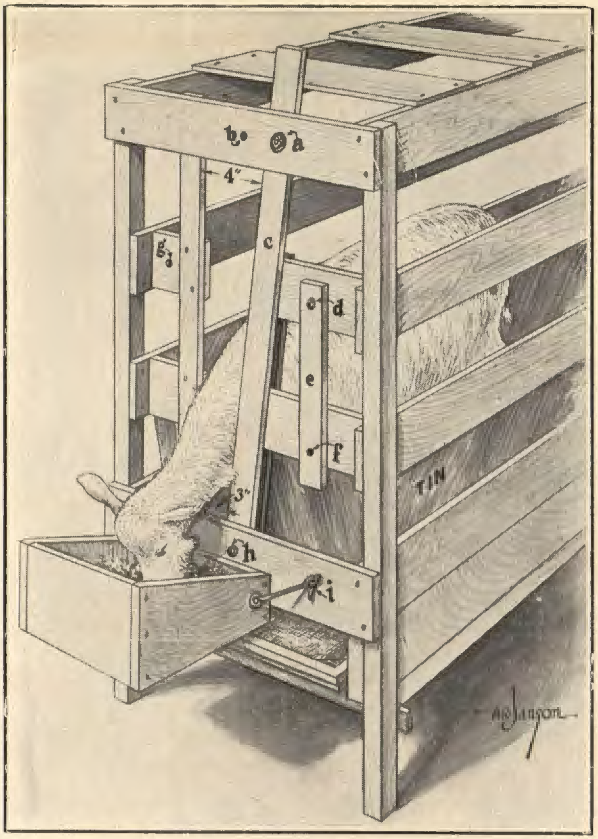



FIGURE 2.

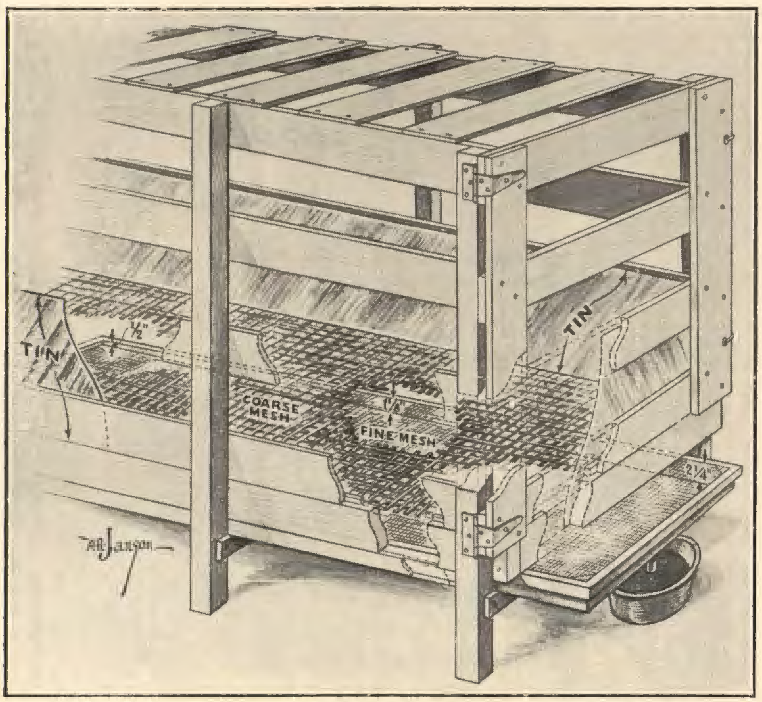



FIGURE 3.

## NON-INFUSORIAN LIFE OF THE RUMEN

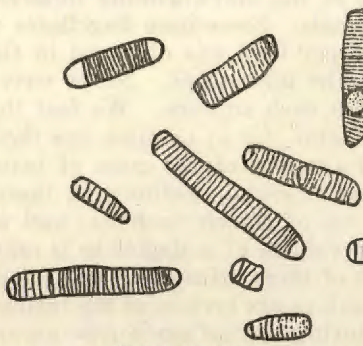
Any adequate presentation of the various factors that obtained in our experiments would require at least brief discussion of the organisms which were present in the rumen of our animals. During the infusoria-free period, as the name implies, there were no infusoria present in the rumen contents of our animals. This was not taken for granted, but the fact was verified by frequent microscopic examinations of samples of rumen contents.

The flagellates *Trichomonas ruminantium* and *Callimastix frontalis* were present to a greater or less degree in our animals during both periods. It seems to be impossible to permanently exclude them, although no other flagellates appeared during the infusoria-free period. It must be emphasized, however, that Callimastix was never abundant and Trichomonas did not at any time abound in the overwhelming numbers that we sometimes find in the stools of animals. Sometimes flagellates were so rare that an average of one flagellate per field was observed in the fraction of a drop under the low power of the microscope. Never were there more than an average of eight or ten in such an area. We feel that the flagellate protozoa were a negligible factor, for at no time was their mass anything like more than a very small fraction of the mass of infusoria during the infected period. According to certain authorities, there may be as many as 2,000,000 infusoria per c.c. of rumen contents; and when we consider the additional facts that the volume of a flagellate is only a small fraction of that of even the smallest of these infusoria, and that they are not ingestors of plant fiber to any extent, as are certain of the infusoria, it is evident that the flagellates present during the infusoria-free period could not have assumed any of the hypothetical rôles attributed to the infusoria.

Bacteria were by far the most numerous organisms present during both periods. No special study was made of them beyond the observations that they were of the rod and coccus types and that Gram's negative greatly preponderated over the Gram's positive. In all four of the animals during both periods there was present in large numbers a rather distinctive, large, Gram's negative, rod-shaped bacterium with rounded ends (fig. 4). Internally it showed what appeared to be transverse partitions. A further peculiarity of this organism was that it stained blue with iodine some time after the animal had received its grain ration, showing that it had absorbed starch.

Did the defaunation process alter the character of the bacterial flora of the rumen? In view of the fact that there is considerable evidence that cellulose digestion in herbivores is accomplished through the agency of bacteria, it was important that this possibility be kept in mind. So little is known about the rumen flora, that it would have been practically impossible for us to have determined whether or not the copper sulphate treatment had produced any change in the cellulose digesting bacterial population. It must be admitted, however, that the large bacterium discussed in the preceding paragraph always disappeared from the rumen simultaneously with the infusoria, and did not return spontaneously, at least in the time allowed. Thus there was a possibility that the character of the bacterial population was considerably changed by the defaunation treatment.

An attempt was made to insure a restoration of the normal flora by reinoculation. This we aimed to accomplish in the following manner: several c.c. of liquid rumen content were taken from a normal goat. This was poured into a test tube and taken out into the cold air or put into a refrigerator for a few minutes. The cooling immobilized the infusoria, and most of them settled to the bottom. A small amount of the remaining bacterial suspension was examined drop by drop under the low power of the microscope for infusoria. Those drops which were free of the protozoa were saved and drawn up into a fine pipette. The contents of this pipette were then injected down the esophagus of the defaunated animal. In all cases we succeeded in effecting the return, within a week or more, of the large rod-like bacterium discussed above, without infecting the defaunated goats



x ca. 1240

**Figure 4.** Large bacillus with appearance of transverse partitions and rounded ends. At upper right is one containing what is possibly a spore.

with infusoria. If any other forms of bacteria had been eliminated they were thus afforded at least an equal opportunity to return. Thus it is quite likely that the floral equilibrium was left not seriously disturbed for the infusoria-free period of the digestion trials.

## THE INFUSORIAN FAUNA

From the tables of Dogiel (1927, pp. 231-234) we learn that there had been recorded from the goat up to that time 19 species of the Ophryoscolecidae. These are divided as follows among the genera of this family: Entodinum, 7; Diplodinium (including all subgenera), 10; Ophryoscolex, 2. Other ciliates which we might expect to find at times in goats are Isotricha, Dasytricha, Buetschlia, or even Charon and Blepharocorys. Becker and Talbott (1927) were inclined to the belief, implied in several places in their paper, that the different form types of Ophryoscolecidae did not necessarily represent species, or even varieties, and that they might be merely transitional forms. Consequently, they adapted a policy of "lumping" as contrasted with Dogiel's policy of "splitting." We now feel that Dogiel has adopted the correct course, for our experience has taught us that when a defaunated animal is inoculated with certain known types, the ensuing fauna developing in its rumen do not offer any striking modifications of the original types. For example, as discussed later, the rumen of a goat into which was introduced a single species, *Entodinium simplex* (?), became infected with types like those in the original inoculation. Other goats inoculated with known species became the hosts of these same specific types.

The importance of recording the species of infusoria present in the rumen during the infected periods of our experiments is apparent. Most of the species of Ophryoscolecidae were determined according to their degree of correspondence with the descriptions of Dogiel (1927). We have not employed sub-generic names. The following table shows the species with which each goat used in the trials was infected.

TABLE 1. *Species of Infusoria Present in Rumen of Each Goat.*

| | |
|---|---|
| Goat 1. | *Entodinium longinucleatum, E. simplex, E. minimum, D. ecaudatum hamatum.* |
| Goat 2. | *Entodinium simplex* (?). |
| Goat 3. | *Entodinium simplex, E. vorax, E. minimum, E. caudatum, Diplodinum ecaudatum hamatum, D. bursa* (See Becker and Talbott for description), *D. multivesiculatum,* and *Isotricha intestinalis.* |
| Goat 4. | Same as Goat 3. |

It will be noted that Goat 2 appeared to have a pure infection of *Entodinium simplex.* The morphology of this ciliate did not check exactly with Dogiel's description, especially in regard to the shape and location of the macronucleus and the nature of the food. Considerable plant fiber, chlorophyll, and starch grains were often found in the endoplasm of our strain. The pure strain was obtained from another goat which originally had a number of species of infusoria. Several attempts to defaunate with acetic acid had eliminated all species but this one, which persisted in coming back.

Perhaps a few words here regarding the life-history and transmission of the ruminant infusoria would not be out of place. Geographically, they seem to be universally distributed. In the rumen they multiply in enormous numbers by binary fission. No authentic cysts of these protozoa have ever been observed, but some of the earlier workers believed the source of the infection to be cysts or resistant forms on the hay. The observation that the infusoria first appeared in lambs at the time they began to eat hay contributed to this belief. Eberlein (1895) and Dogiel (1927) have observed that when different species of ruminants were thrown into proximity each species is likely to acquire a mixed fauna. While this type of observation does not bear exactly upon the question of the existence of cysts, it implies that there is no universal distribution of resistant forms on herbage. Otherwise, a mixing of the faunas would occur without the animals being brought into proximity. Becker and Hsiung (1929) have shown that in all probability cysts do not exist, and that the infection is spread by contamination of feed with trophozoites in the saliva from the mouth. That the fauna is at least somewhat non-specific was shown by these same workers, for they were able to infect defaunated goats with infusoria from cattle, and sheep with those from goats. Eberlein (1895) had previously observed that wild ruminants brought into a zoo acquired the fauna of the domestic ruminants of the region. Dogiel (1927) also made observations contributing to the idea that there is no rigid host-specificity, although there is evidence for some degree of it.

Weill (1929) has recently made the novel and interesting suggestion that certain insects may have a rôle in the transmission of ruminant infusoria. This idea is based upon his discovery of an Isotricha in the intestine of a cockroach. There are a number of reasons why such a method of transmission seems to us to be improbable, but the problem is now before us and demands more investigation.

No satisfactory method of cultivating these protozoa has been developed as yet. Among those who have made efforts in this direction are Coste (1864), Edwards (1864), Pouchet (1864), Schuberg (1888), Certes (1889), Günther (1899), Fiebiger (1923), and Becker and Talbott (1927). Knoth (1928), with his hay cultures, has come the nearest of all to success. His method was unique in that he replaced the air in the suction flasks containing his culture medium and infusoria with a gaseous mixture consisting of 65 per cent $CO_2$ and 35 per cent methane, which he found to be the proportions present in the normal rumen. Magnesium oxide was added to the medium to neutralize the acids produced. The pH was kept as near 6.8 as possible. Some of his infusoria lived for 107 hours.

## CHEMICAL ANALYSIS

Moisture content of feeds and feces was determined by heating the samples to a constant weight in a Freas vacuum oven at a temperature of 60°C and in a vacuum of 26 to 29 in. of mercury.

Ash, crude protein, ether extract, and pentosans were determined according to the Official Methods of Analysis of the Association of Official Agricultural Chemists (1925).

Alpha, true or normal cellulose (Cross and Bevan, 1916) was determined by treating the samples with four per cent NaOH at 180 pounds pressure for one hour according to the method of Mehta (1925).

The hemicelluloses were determined by hydrolysing the material with 2.5 per cent $H_2SO_4$ (by weight) for two hours. After filtration, neutralization, clarification with neutral lead acetate, and removal of excess lead with dry $NaHCO_3$, the reducing sugars in the filtrates were determined as dextrose by the method of Quisumbing (1921).

Crude fiber was determined by the Morgan O. Sweeney method as modified by Kennedy (1912).

Tables 2 to 9, inclusive, present the percentage constituents of feeds and excreta, the intake and excretion of nutrients, and the amounts of each nutrient digested by each goat during each period. Attention is called particularly to the fact that the percentage of nitrogen or protein in the feces of all animals was greater in the case of the feces voided during the first period. The total amount of nitrogen excreted in the urine was, however, greater for each goat during the second period. But in the case of Goat 1 more feed was fed during the second period.

Table 10 shows, for both periods, the coefficients of digestibility of all nutrients, the nitrogen balance, the partition of the nitrogen excretion, the nutritive ratio of the rations, and the weights of the goats.

It was originally planned to include in the experiment the ash, calcium, magnesium, and phosphorus balances, but it was discovered that the distilled water available had a deleterious effect upon the growth and multiplication of the infusoria in the rumen when given to the animals for drink. Qualitative chemical tests upon the slight residues obtained by evaporating large quantities of the distilled water used failed to show the presence of copper or any other metals which might conceivably cause this deleterious effect. The residue consisted largely of silicate salts derived probably from the storage containers or glassware. Therefore, tap water was fed to the goats; and since under the conditions of the experiment ash and mineral balances were not considered essential to the purposes and ends in view, no attempt was made either to analyze the water or to record the amounts drunk by the animals.

While the chemical and biological literature contains hundreds of papers, which record the results of digestion and metabolism trials with steers, dairy cattle, pigs and sheep, there are but few experiments published which can be used for close comparisons. A search through the extensive literature on the metabolism and digestion of ruminants reveals but few cases in which goats were used and results other than merely the mineral balances were published. Most of this material is older work, and was planned to determine the digestibility of single roughages and feeds, or to show how the addition of certain feeds, chemicals, or supplements modified the digestion and utilization of the feed, or the milk production of the animal. The researches of Emery and Kilgore (1892, 1894), Fingerling (1911 (a) and (b)), Morgen, Beger and Westhauser (1909, 1910), and Snyder (1893) are typical, but because of the differences in the character of the rations used, and the procedures followed, the results obtained can not be compared too directly with the results we have obtained upon the coefficients of digestibility of the nutrients in our ration. We do find, however, that our digestion coefficients do fall well within the limits established by these early investigations, wherever the rations and animals are at all comparable, for the nutrients studied by them. A more recent publication by Hunt, Winter, Schulz and Miller (1923) offers a somewhat closer basis of comparison, especially during those periods in which dry feeds were fed. We were unable to find any records of previous reports upon the digestion coefficients of alpha cellulose, pentosans and hemicelluloses where goats were used as the experimental animals.

Considering the fact that the goats used in this experiment were of varying breeds, sizes and ages, the coefficients of digestibility of the nutrients studied present a normal agreement. The maximum variation in the percentages of digestibility was 16.07 per cent, shown, as would be expected from the results of other investigators, by the ether extract. The variation in the digestion coefficients of the cellulose materials varied from 7.30 per cent for alpha cellulose, and 5.85 per cent for hemicellulose to 1.83 per cent for the pentosans. There was a normal variation of 2.97 per cent in the digestibility of the protein, of 3.54 per cent, and 3.41 per cent in the digestibility of the nitrogen-free extract and total dry matter, respectively.

The variation in the ability to digest crude fiber and hemicellulose as shown by Goat 1 in periods I and II was greater than that exhibited by the other goats in comparison with each other, or with Goat 1. This may be due to the fact that Goat 1 was probably somewhat under-fed during the first period.

The coefficients of digestibility of all nutrients, as determined by us, compare favorably with those determined by other investigators, with the possible exception that our figures for the digestibility of crude fiber are somewhat lower than those reported by some investigators using goats in their studies. This difference in results is possibly due to the fact that the alfalfa hay used by us, while containing a good percentage of protein (tables 2 to 9) was somewhat dark in color, contained a rather high percentage of stems, and had undoubtedly weathered slightly. It was, however, the best hay available at the time.

All of the goats used in this experiment stored some nitrogen, the daily storage varying from 0.37 grams by Goat 3 in period II, to 4.84 grams by Goat 2 in period I. No attempt was made to estimate the nitrogen loss from the body through perspiration, or by the collection of brushings. These positive nitrogen balances, while small, indicate that the animals, though apparently receiving, designedly, rather meager rations, and in some cases losing weight during the progress of the experiment, were neverthelss in a fair state of nutrition so far as their protein requirements were concerned. Only Goat 2, during period I, excreted a greater percentage of her total excreted nitrogen in the feces than in the urine. This goat may have been underfed before being placed on experiment, stored nitrogn consistently while on experiment, and probably could have received more feed, without danger of going stale or refusing feed.

## THE EFFECTS OF INFUSORIA ON DIGESTION

A perusal of table 10 indicates that on the whole the presence or absence of infusoria, in the rumens of these goats had but little demonstrated effect upon the coefficients of digestibility of the nutrients. Goats 1 and 2, young, immature, and growing before and after being placed on experiment, digested slightly greater percentages of all nutrients (with the exception of pentosan in the case of Goat 2, and ether extract in the cases of both goats) while they were infected with infusoria. Goat 3 digested smaller percentages of all nutrients, except protein and ether extract, while infected with protozoa, while Goat 4 digested greater percentages of all nutrients except crude fiber, pentosan and alpha cellulose while thus infected.

Larger percentages of dry matter, hemicellulose, and nitrogen-free extract were digested by three out of four goats while infected with infusoria. Only two out of the four goats increased their percentage digestion of ether extract, crude fiber and alpha cellulose when thus infected; and only one, Goat 1, digested a higher percentage of pentosan material while harboring these infusoria. Since certain previously cited publications have indicated the possibility that infusoria have some part in the digestion of cellulose in ruminants, it was in the digestion of the cellulose materials that we expected to find the greatest differences. Goat 1 was the only one of our experimental animals, however, which digested appreciably greater amounts of the cellulose material while infected with infusoria, and even these differences in digestive ability are probably too small to be of any practical significance. At any rate, any apparent significance which they might have is probably nullified by the fact that the more mature goats, 3 and 4, digested with the one exception of hemicellulose, greater percentages of crude fiber, alpha cellulose and hemicellulose in the periods when they were free from infusorial infection.

While it is true that the average figures for the coefficients of digestibility for the four goats are slightly greater, with the exception of the figure for pentosan, in those periods when the goats were infected with infusoria, it may be seen that these average figures are in most cases greater because of the results obtained from one goat out of the four. Our only complete unanimity between the four goats was obtained in the digestion of protein, all goats digesting slightly more protein during those periods when they were infected with infusoria. These results on the digestion of protein may offer some slight support to theories propounded to the effect that the infusoria may manufacture proteins from non-protein nitrogen compounds, or otherwise exert a protein sparing action in the paunch of ruminants. Since, however, the largest increase present, obtained with Goat 1, was less than five per cent of the total percentage of protein digested, and since an increase in protein storage followed infection with infusoria in only two goats out of the four, we feel that our results on protein digestion thus far offer little more than a possible encouragement to the further study of the relation between infusoria and the digestion of protein in ruminants. Since (tables 2 to 9) the percentages of protein present in the feces were found to be greater in the feces voided by all goats during the first period, when the goats were infusoria free, it may seem that the protein constituting the bodies of the infusoria may have been more easily digested than that of the plant foods in the ration fed. These differences in the percentages of protein present in the feces voided during the two periods by each goat are possibly small enough to be accounted for by the bodies of the infusoria; and if so, the differences in the digestibility coefficients for the proteins during the two periods might not lend support to any theory of protein sparing action by the infusoria which does not first presuppose the changing of plant nitrogen into infusorial proteins. Thus it would be possible from our results to deduce the theory that the infusoria may be benign and very slightly useful parasites. Any further studies should probably be made upon the rumen contents by means of fistulae rather than upon the feces and urine, since it is quite possible that the bacteria in the intestinal tract obliterate at least some of the changes in the protein metabolism which may have been initiated by infusoria in the rumen.

## THE EFFECT OF THE PROTOZOA ON pH AND ON PUTREFACTION

The pH of rumen contents of Goat 1 was taken on two different days during each period by the color method. They were as follows: infusoria free period, 7.2 and 7.4; infected period, 7.4 and 7.2. Tests on some of the other goats during both periods gave similar results. At any rate, the pH is not affected by the protozoa.

It seems untenable that the infusoria may aid their host in keeping down the growth of microörganisms which, if unchecked, might become injurious. No untoward effects on the health have been observed in these and other goats. One of these was free of infusoria for over six months. Likewise, the infusoria-free lambs of Becker and Everett (1929) showed a healthy rate of growth. The Ehrlich test for putrefaction (indol) made several times on rumen contents of Goat 1 during the infusoria-free period gave only negative results. Consequently, we cannot ascribe to the infusoria any rôle in keeping down the growth of injurious microörganisms of the nature of Schizomycetes.

## DISCUSSION AND SUMMARY

Let us discuss briefly the bearing of the results of our experiments and observations upon each of the previously held views regarding the relationships between the rumen infusoria of ruminants and their hosts.

That the infusoria convert plant substances into the animal substance of their own bodies, and that these in turn are sacrificed to the digestive juices in the stomach and intestine, are matters of common observation. That the host animal derives any substantial benefit from possible activities of the infusoria, such as either synthesizing proteins from simpler nitrogenous substances as amides or converting plant protein into a more easily digestible animal protein, as discussed above, is doubtful. Mangold (1929) has recently discussed the results of the work of Ferber (1928), who failed to secure any consistent increase in the numbers of infusoria by adding urea and ammonium acetate to protein poor and carbohydrate rich feeds. Our results are consistent with these findings, but certainly not with these authors' conclusions that "Offenbar erleichtern die Panseninfusorien dem Wiederkäuer die Eiweiss-Ausnutzung indem sie das schwerer verdauliche, pflanzliche Eiweiss seines Futters zunächst in das leichter verdauliche Eiweiss ihrer eigenen Leibessubstanz umwandeln." Neither are our results nor the recently reported results of Becker and Everett (1929), in which infusoria-free lambs made somewhat greater gains in weight than infected lambs, lend support to such a hypothesis.

If the slightly lower protein content of the feces in our infected animals represents an actuality, and is not due to chance, it does not necessarily signify any advantage to the animal, for it must be remembered that the infusoria themselves metabolize a certain amount of protein. Thus it is even possible that they may represent a liability rather than an asset in the economy of the animal. If this should prove to be true, the protozoa could be regarded as harmful parasites only in the rôle of "food-robbers."

It should be mentioned here that protein synthesis from amides in the paunch of ruminants is by no means proved, although the early work of Zuntz (1891, 1913), Hagemann (1891), and others (Müller, Hansen) seemed to supply much evidence for it. Mangold (1929) has discussed some of the more recent negative results. There still will be time for determining whether it is the protozoa or the bacteria that are responsible for protein synthesis after it is positively determined whether or not such synthesis actually takes place.

As discussed above, the infusoria are not to be regarded as a natural restraining influence upon the inordinate multiplication of the Schizomycetes in the rumen. Many of these infusoria eat some bacteria, but activities of this nature are of no noticeable consequence on the health of the host.

As regards cellulose digestion, our figures for the amounts of it digested in infusoria-free and infected animals show little difference. We wish to make one point clear—we do not wish to commit ourselves at present on the controversial point as to whether or not some or all of the Ophryoscolecidae can digest cellulose. Our problem is one of host-parasite relationships rather than one of the physiology of digestion inside a protozoon. According to Trier (1926), these infusoria can digest starch, converting it into glycogen. According to Ferber (1928), they can ingest fat, and digest it with the aid of certain bacteria. But we do not know for sure if they can digest cellulose (*Vide ut supra*). Our contribution consists in the simple discovery that cellulose digestion in the host is neither due to, nor assisted materially by the infusoria.

The suggestion of Trier (1928) that there may be a symbiosis between infusoria and cellulose-digesting bacteria is likewise untenable, for cellulose digestion took place in animals free from infusoria for weeks.

Incidentally, one sometimes hears that it is still uncertain that animals can digest true cellulose. This doubt was echoed by Cleveland (1925). We have found that the goat digests crude fiber, hemicelluloses, alpha cellulose, and pentosans in considerable amounts (see tables).

The suggestions, discussed above, that the infusoria may be valuable in purely mechanical ways (thorough mixing and trituration of the rumen contents) likewise seem to be unsubstantiated by our experiences. Digestion seems to have progressed as well in an infusoria-free goat as in an infected one. Likewise, there were no rumen impactions or complications due to mechanical causes. It is true that these goats were not permitted to engorge to capacity. The lambs of Becker and Everett (1929), however, did have this privilege. These animals have not experienced any rumen difficulties to date.

After eliminating serious consideration of all other hypotheses, there still remains the view that the rumen infusoria are mere commensals. We feel more closely committed to this one than to any of the others.

## CONCLUSIONS

1. The infusoria of the ruminant stomach are of no substantial value to their host in converting plant proteins into more easily digestible animal protoplasm.
2. It is doubtful if they can convert amides or protein derivatives into the protein of their own bodies.
3. They are of no appreciable value to their host in the digestion of carbohydrates.
4. There is no demonstrable symbiosis between the infusoria and cellulose-digesting bacteria of the rumen.
5. They serve no significantly useful purpose in suppressing the numbers of Schizomycetes in the rumen.
6. They apparently perform no mechanical services of any value by way of mixing, triturating, or soaking the roughage in the rumen.
7. They exert no effect upon the hydrogen-ion concentration of the rumen.
8. The physical well-being of the host is not perceptibly improved by removal of this fauna.
9. Since there is no reason for regarding these infusoria either as constituting a useful endofauna or true parasites, we must consign them definitely, for the present, to the status of mere commensals.
10. It remains to be seen whether or not they may be "food-robbers" to a limited extent.

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## ADDENDUM

Since this paper was accepted for publication, one of us (E. R. B.), has received from Dr. Ernst Mangold, the director of animal physiology in the Landwirtschaftlichen Hochschule in Berlin, his work, embracing 237 pages, on the digestion of ruminants from the *Handbuch der Ernährung und des Stoffwechsels der landwirtschaftlichen Nutztiere,* published in 1929 by J. Springer of Berlin. Twenty-six pages of this work (pp. 156-182) are devoted to a comprehensive discussion of the infusoria of ruminants. The author considers that it is almost proved that the relationship between the infusoria and their host is one of symbiosis. The work carried on under his direction, mentioned in our paper, is extensively reviewed in support of his contentions. Since we shall discuss his findings relating to the infusoria more critically in a later paper, we shall use this opportunity to call attention to this excellent presentation of the subject and to thank Dr. Mangold for the copy of his work.

| | Pct. $H_2O$ | Pct. dry matter | Pct. protein | Pct. ether extract | Pct. ash | Pct. N. F. extract | Pct. crude fiber | Pct. hemi cellulose calc'd as dextrose | Pct. pentosan | Pct. alpha cellulose | Amounts fed or voided gms. | Amts. fed or voided as analyzed gms. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hay | 6.29 | 93.71 | 16.38 | 1.93 | 9.77 | 33.06 | 32.57 | 7.83 | 12.76 | 19.03 | 2975 | 2847 |
| Grain | 7.96 | 92.04 | 14.81 | 4.46 | 4.42 | 59.24 | 9.11 | 11.90 | 11.31 | 6.27 | 1960 | 1960 |
| Feces | 6.15 | 93.85 | 13.37 | 2.46 | 9.13 | 29.31 | 39.58 | 14.03 | 16.61 | 20.14 | 1813 | 1807 |
| Urine | | | 3.32 | | | | | | | | 10,772 | 10,772 |

Intake of nutrients

| | Feed corrected gms. | Nitrogen gms. | Protein gms. | Ether extract gms. | Ash gms. | N. F. extract gms. | Crude fiber gms. | Hemi cellulose calc'd as dextrose gms. | Pentosans gms. | Alpha cellulose gms. | Dry matter gms. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Hay | 2847 | 74.56 | 466.34 | 54.95 | 278.15 | 941.22 | 927.27 | 222.92 | 363.28 | 541.78 | 2667.92 |
| Grain | 1960 | 46.45 | 290.28 | 87.41 | 86.63 | 1161.10 | 178.56 | 233.24 | 222.26 | 122.89 | 1803.98 |
| Total per period | 3807 | 121.01 | 756.62 | 142.36 | 364.78 | 2102.32 | 1105.83 | 456.16 | 585.54 | 664.67 | 4471.90 |
| Per day | | 8.64 | 54.04 | 10.17 | 26.06 | 150.17 | 78.99 | 32.58 | 41.82 | 47.48 | 319.42 |

Excretion of nutrients

| | Voided corrected gms. | Nitrogen gms. | N calc'd as Protein gms. | Ether extract gms. | Ash gms. | N. F. extract gms. | Crude fiber gms. | Hemi cellulose calc'd as dextrose gms. | Pentosans gms. | Alpha cellulose gms. | Dry matter gms. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Feces | 1807 | 38.66 | 241.60 | 44.45 | 164.98 | 529.63 | 715.21 | 253.52 | 300.14 | 363.93 | 1695.87 |
| Urine | 10,772 | 57.22 | 357.63 | | | | | | | | |
| Total per period | | 95.88 | 599.23 | 44.45 | 164.98 | 529.63 | 715.21 | 253.52 | 300.14 | 363.93 | 1695.87 |
| Per day | | 6.85 | 42.80 | 3.18 | 11.78 | 37.83 | 51.09 | 18.11 | 21.44 | 26.00 | 121.13 |
| Grams digested | | | 515.02 | 97.91 | | 1572.69 | 390.62 | 202.64 | 285.40 | 300.74 | 2776.03 |

TABLE 3. *Feeds and Excreta of Goat 1 for Period II (14 Days).*
Percentage composition of feeds and excreta

| | Pct. $H_2O$ | Pct. dry matter | Pct. protein | Pct. ether extract | Pct. ash | Pct. N. F. extract | Pct. crude fiber | Pct. hemi cellulose calc'd as dextrose | Pct. pentosan | Pct. alpha cellulose | Amounts fed or voided gms. | Amts. fed or voided as analyzed gms. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hay | 6.29 | 93.71 | 16.38 | 1.93 | 9.77 | 33.06 | 32.57 | 7.83 | 12.76 | 19.03 | 3966.67 | 3796.18 |
| Grain | 7.96 | 92.04 | 14.81 | 4.46 | 4.42 | 59.24 | 9.11 | 11.90 | 11.31 | 6.27 | 1960 | 1960 |
| Feces | 10.83 | 89.17 | 12.03 | 2.36 | 10.20 | 26.30 | 38.28 | 12.04 | 15.93 | 18.78 | 2215 | 2191 |
| Urine | | | 4.38 | | | | | | | | 10,392 | 10,392 |

Intake of nutrients

| | Feed corrected gms. | Nitrogen gms. | Protein gms. | Ether extract gms. | Ash gms. | N. F. extract gms. | Crude fiber gms. | Hemi cellulose calc'd as dextrose gms. | Pentosans gms. | Alpha cellulose gms. | Dry matter gms. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Hay | 3796.18 | 99.49 | 621.81 | 73.27 | 370.89 | 1255.02 | 1236.42 | 297.24 | 484.39 | 722.41 | 3557.40 |
| Grain | 1960 | 46.44 | 290.28 | 87.42 | 86.63 | 1161.10 | 178.56 | 233.24 | 221.68 | 122.89 | 1803.98 |
| Total per period | | 145.93 | 912.09 | 160.69 | 457.52 | 2416.12 | 1414.98 | 530.48 | 706.07 | 845.30 | 5361.38 |
| Per day | | 10.42 | 65.15 | 11.48 | 32.68 | 172.58 | 101.07 | 37.89 | 50.43 | 60.38 | 382.96 |

Excretion of nutrients

| | Voided corrected gms. | Nitrogen gms. | N calc'd as Protein gms. | Ether extract gms. | Ash gms. | N. F. extract gms. | Crude fiber gms. | Hemi cellulose calc'd as dextrose gms. | Pentosans gms. | Alpha cellulose gms. | Dry matter gms. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Feces | 2191 | 42.17 | 263.58 | 51.71 | 223.48 | 576.23 | 838.71 | 263.80 | 349.03 | 411.47 | 1953.71 |
| Urine | 10,392 | 72.83 | 455.17 | | | | | | | | |
| Total per period | | 115.00 | 718.75 | 51.71 | 223.48 | 576.23 | 838.71 | 263.80 | 349.03 | 411.47 | 1953.71 |
| Per day | | 8.21 | 51.34 | 3.69 | 15.96 | 41.16 | 59.91 | 18.84 | 24.93 | 29.39 | 139.55 |
| Grams digested | | | 648.51 | 108.98 | | 1839.89 | 576.27 | 266.68 | 357.04 | 433.83 | 5407.67 |

TABLE 4. *Feeds and Excreta of Goat 2 for Period I (14 Days).*
Percentage composition of feeds and excreta

TABLE 4. *Feeds and Excreta of Goat [illegible] for Period [illegible] (14 Days).*

Percentage composition of feeds and excreta

| | Pct. $H_2O$ | Pct. dry matter | Pct. protein | Pct. ether extract | Pct. ash | Pct. N. F. extract | Pct. crude fiber | Pct. hemi cellulose calc'd as dextrose | Pct. pentosan | Pct. alpha cellulose | Amounts fed or voided gms. | Amts. fed or voided as analyzed gms. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hay | 6.29 | 93.71 | 16.38 | 1.93 | 9.77 | 33.06 | 32.57 | 7.83 | 12.76 | 19.03 | 4760 | 4555 |
| Grain | 5.45 | 94.55 | 13.15 | 4.13 | 6.45 | 63.63 | 7.19 | 10.60 | 10.60 | 4.65 | 2100 | 1871 |
| Feces | 6.33 | 93.67 | 12.92 | 2.95 | 10.75 | 26.85 | 40.20 | 11.81 | 15.45 | 19.49 | 2524 | 2524 |
| Urine | | | 2.42 | | | | | | | | 10,013 | 10.013 |

Intake of nutrients

| | Feed corrected gms. | Nitrogen gms. | Protein gms. | Ether extract gms. | Ash gms. | N. F. extract gms. | Crude fiber gms. | Hemi cellulose calc'd as dextrose gms. | Pentosans gms. | Alpha cellulose gms. | Dry matter gms. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Hay | 4555 | 119.38 | 746.11 | 87.91 | 455.02 | 1505.88 | 1483.56 | 356.66 | 581.22 | 866.82 | 4268.49 |
| Grain | 1871 | 39.37 | 246.04 | 77.27 | 120.68 | 1190.52 | 134.52 | 198.33 | 198.33 | 87.00 | 1769.03 |
| Total per period | | 158.75 | 992.15 | 165.18 | 565.70 | 2696.40 | 1618.08 | 554.99 | 779.55 | 953.82 | 6037.52 |
| Per day | | 11.34 | 70.87 | 11.80 | 40.41 | 192.60 | 115.58 | 39.64 | 55.68 | 68.13 | 431.25 |

Excretion of nutrients

| | Voided corrected gms. | Nitrogen gms. | N calc'd as Protein gms. | Ether extract gms. | Ash gms. | N. F. extract gms. | Crude fiber gms. | Hemi cellulose calc'd as dextrose gms. | Pentosans gms. | Alpha cellulose gms. | Dry matter gms. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Feces | 2524 | 52.18 | 326.10 | 74.46 | 271.33 | 677.69 | 1014.65 | 298.08 | 389.96 | 491.93 | 2364.23 |
| Urine | 10,013 | 38.77 | 242.31 | | | | | | | | |
| Total per period | | 90.95 | 568.41 | 74.46 | 271.33 | 677.69 | 1014.65 | 298.08 | 389.96 | 491.93 | 2364.23 |
| Per day | | 6.50 | 40.60 | 5.32 | 19.38 | 48.41 | 72.48 | 21.29 | 27.85 | 35.14 | 168.87 |
| Grams digested | | | 666.05 | 90.72 | | 2018.71 | 603.43 | 256.91 | 380.59 | 461.89 | 3673.29 |

TABLE 5. *Feeds and Excreta of Goat 2 for Period II (14 Days).*

Percentage composition of feeds and excreta

| | Pct. $H_2O$ | Pct. dry matter | Pct. protein | Pct. ether extract | Pct. ash | Pct. N. F. extract | Pct. crude fiber | Pct. hemi cellulose calc'd as dextrose | Pct. pentosan | Pct. alpha cellulose | Amounts fed or voided gms. | Amts. fed or voided as analyzed gms. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hay | 6.29 | 93.71 | 16.38 | 1.93 | 9.77 | 33.06 | 32.57 | 7.83 | 12.76 | 19.03 | 4760 | 4555 |
| Grain | 5.45 | 94.55 | 13.15 | 4.13 | 6.45 | 63.63 | 7.19 | 10.60 | 10.60 | 4.65 | 2100 | 1871 |
| Feces | 6.82 | 93.18 | 12.59 | 3.16 | 11.09 | 25.67 | 40.67 | 11.62 | 15.87 | 19.39 | 2460 | 2460 |
| Urine | | | 2.90 | | | | | | | | 12,363 | 12,363 |

Intake of nutrients

| | Feed corrected gms. | Nitrogen gms. | Protein gms. | Ether extract gms. | Ash gms. | N. F. extract gms. | Crude fiber gms. | Hemi cellulose calc'd as dextrose gms. | Pentosans gms. | Alpha cellulose gms. | Dry matter gms. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Hay | 4555 | 119.38 | 746.11 | 87.91 | 445.02 | 1505.88 | 1483.56 | 356.66 | 581.22 | 866.82 | 4268.49 |
| Grain | 1871 | 39.37 | 246.04 | 77.27 | 120.68 | 1190.52 | 134.52 | 198.33 | 198.33 | 87.00 | 1769.03 |
| Total per period | | 158.75 | 992.15 | 165.18 | 565.70 | 2696.40 | 1618.08 | 554.99 | 779.55 | 953.82 | 6037.52 |
| Per day | | 11.34 | 70.87 | 11.80 | 40.41 | 192.60 | 115.58 | 39.64 | 55.68 | 68.13 | 431.25 |

Excretion of nutrients

| | Voided corrected gms. | Nitrogen gms. | N calc'd as Protein gms. | Ether extract gms. | Ash gms. | N. F. extract gms. | Crude fiber gms. | Hemi cellulose calc'd as dextrose gms. | Pentosans gms. | Alpha cellulose gms. | Dry matter gms. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Feces | 2460 | 49.55 | 309.71 | 77.74 | 272.82 | 631.48 | 1000.48 | 285.85 | 390.40 | 476.99 | 2292.23 |
| Urine | 12,363 | 57.36 | 358.53 | | | | | | | | |
| Total per period | | 106.91 | 668.24 | 77.74 | 272.82 | 631.48 | 1000.48 | 285.85 | 390.40 | 476.99 | 2292.23 |
| Per day | | 7.64 | 47.73 | 5.55 | 19.49 | 45.11 | 71.46 | 20.42 | 27.89 | 34.07 | 163.73 |
| Grams digested | | | 682.44 | 87.44 | | 2064.92 | 617.60 | 269.14 | 389.15 | 476.83 | 3745.29 |

Percentage composition of feeds and excreta

| | Pct. $H_2O$ | Pct. dry matter | Pct. protein | Pct. ether extract | Pct. ash | Pct. N. F. extract | Pct. crude fiber | Pct. hemi cellulose calc'd as dextrose | Pct. pentosan | Pct. alpha cellulose | Amounts fed or voided gms. | Amts. fed or voided as analyzed gms. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hay | 6.07 | 93.93 | 14.79 | 2.04 | 9.85 | 32.98 | 34.27 | 7.83 | 12.65 | 20.24 | 8666.7 | 7999 |
| Grain | 7.26 | 92.74 | 12.94 | 4.02 | 6.42 | 62.29 | 7.07 | 10.55 | 10.70 | 4.64 | 3150 | 3150 |
| Feces | 6.40 | 93.60 | 12.13 | 2.94 | 11.03 | 25.37 | 42.13 | 11.54 | 15.22 | 19.57 | 4280 | 4280 |
| Urine | | | 6.55 | | | | | | | | 14,490 | 14,490 |

Intake of nutrients

| | Feed corrected gms. | Nitrogen gms. | Protein gms. | Ether extract gms. | Ash gms. | N. F. extract gms. | Crude fiber gms. | Hemi cellulose calc'd as dextrose gms. | Pentosans gms. | Alpha cellulose gms. | Dry matter gms. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Hay | 7999 | 189.29 | 1183.05 | 163.18 | 787.90 | 2638.07 | 2741.26 | 626.32 | 1014.27 | 1619.00 | 7513.46 |
| Grain | 3150 | 65.22 | 407.61 | 126.63 | 202.23 | 1962.14 | 222.71 | 332.33 | 337.05 | 146.16 | 2921.31 |
| Total per period | | 254.51 | 1590.66 | 289.81 | 990.13 | 4600.21 | 2963.97 | 958.65 | 1351.32 | 1765.16 | 10,434.77 |
| Per day | | 12.12 | 75.75 | 13.80 | 47.15 | 219.06 | 141.14 | 45.65 | 64.35 | 84.06 | 496.89 |

Excretion of nutrients

| | Voided corrected gms. | Nitrogen gms. | N calc'd as Protein gms. | Ether extract gms. | Ash gms. | N. F. extract gms. | Crude fiber gms. | Hemi cellulose calc'd as dextrose gms. | Pentosans gms. | Alpha cellulose gms. | Dry matter gms. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Feces | 4280 | 83.07 | 519.16 | 125.83 | 472.08 | 1085.84 | 1803.16 | 493.91 | 651.42 | 837.60 | 4006.08 |
| Urine | 14,490 | 151.85 | 949.10 | | | | | | | | |
| Total per period | | 234.92 | 1468.26 | 125.83 | 472.08 | 1085.84 | 1803.16 | 493.91 | 651.42 | 837.60 | 4006.08 |
| Per day | | 11.19 | 69.92 | 5.99 | 22.48 | 51.71 | 85.86 | 23.52 | 31.02 | 39.89 | 190.77 |
| Grams digested | | | 1071.50 | 163.98 | | 3514.37 | 1160.81 | 464.74 | 699.90 | 927.56 | 6428.69 |

TABLE 7. *Feeds and Excreta of Goat 3 for Period II (21 Days).*
Percentage composition of feeds and excreta

| | Pct. $H_2O$ | Pct. dry matter | Pct. protein | Pct. ether extract | Pct. ash | Pct. N. F. extract | Pct. crude fiber | Pct. hemi cellulose calc'd as dextrose | Pct. pentosan | Pct. alpha cellulose | Amounts fed or voided gms. | Amts. fed or voided as analyzed gms. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hay | 6.07 | 93.93 | 14.79 | 2.04 | 9.85 | 32.98 | 34.27 | 7.83 | 12.68 | 20.24 | 8666.7 | 7999 |
| Grain | 7.26 | 92.74 | 12.94 | 4.02 | 6.42 | 62.29 | 7.07 | 10.55 | 10.70 | 4.64 | 3150 | 3150 |
| Feces | 7.03 | 92.97 | 11.40 | 2.69 | 10.95 | 26.23 | 41.70 | 11.66 | 15.53 | 19.34 | 4334 | 4334 |
| Urine | | | 7.17 | | | | | | | | 14,610 | 14,610 |

Intake of nutrients

| | Feed corrected gms. | Nitrogen gms. | Protein gms. | Ether extract gms. | Ash gms. | N. F. extract gms. | Crude fiber gms. | Hemi cellulose calc'd as dextrose gms. | Pentosans gms. | Alpha cellulose gms. | Dry matter gms. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Hay | 7999 | 189.29 | 1183.05 | 163.18 | 787.90 | 2638.07 | 2741.26 | 626.32 | 1014.27 | 1619.00 | 7513.46 |
| Grain | 3150 | 65.22 | 407.61 | 126.63 | 202.23 | 1962.14 | 222.71 | 332.33 | 337.05 | 146.16 | 2921.31 |
| Total per period | | 254.51 | 1590.66 | 289.81 | 990.13 | 4600.21 | 2963.97 | 958.65 | 1351.32 | 1765.16 | 10,434.77 |
| Per day | | 12.12 | 75.75 | 13.80 | 47.15 | 219.06 | 141.14 | 45.65 | 64.35 | 84.06 | 496.89 |

Excretion of nutrients

| | Voided corrected gms. | Nitrogen gms. | N calc'd as Protein gms. | Ether extract gms. | Ash gms. | N. F. extract gms. | Crude fiber gms. | Hemi cellulose calc'd as dextrose gms. | Pentosans gms. | Alpha cellulose gms. | Dry matter gms. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Feces | 4334 | 79.05 | 494.08 | 116.58 | 474.57 | 1136.81 | 1807.28 | 505.34 | 673.07 | 838.20 | 4029.32 |
| Urine | 14,610 | 167.61 | 1047.54 | | | | | | | | |
| Total per period | | 246.66 | 1541.62 | 116.58 | 474.57 | 1136.81 | 1807.28 | 505.34 | 673.07 | 838.20 | 4029.32 |
| Per day | | 11.75 | 73.41 | 5.55 | 22.60 | 54.13 | 86.06 | 24.06 | 32.05 | 39.91 | 191.87 |
| Grams digested | | | [illegible] | [illegible] | | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] | [illegible] |

Percentage composition of feeds and excreta

| | Pct. $H_2O$ | Pct. dry matter | Pct. protein | Pct. ether extract | Pct. ash | Pct. N. F. extract | Pct. crude fiber | Pct. hemi cellulose calc'd as dextrose | Pct. Pentosans | Pct. alpha cellulose | Amounts fed or voided gms. | Amts. fed or voided as analyzed gms. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hay | 6.29 | 93.71 | 16.38 | 1.93 | 9.77 | 33.06 | 32.57 | 7.83 | 12.76 | 19.03 | 8925 | 8541 |
| Grain | 5.45 | 94.55 | 13.15 | 4.13 | 6.45 | 63.63 | 7.19 | 10.60 | 10.60 | 4.65 | 3150 | 2806 |
| Feces | 6.92 | 93.08 | 12.05 | 2.91 | 10.50 | 27.44 | 40.18 | 11.49 | 15.08 | 18.96 | 4562 | 4562 |
| Urine | | | 4.19 | | | | | | | | 20,642 | 20,642 |

Intake of Nutrients

| | Feed corrected gms. | Nitrogen gms. | Protein gms. | Ether extract gms. | Ash gms. | N. F. extract gms. | Crude fiber gms. | Hemi cellulose calc'd as dextrose gms. | Pentosans gms. | Alpha cellulose gms. | Dry matter gms. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Hay | 8541 | 223.84 | 1399.02 | 164.84 | 834.46 | 2823.65 | 2781.80 | 668.76 | 1089.83 | 1625.35 | 8003.77 |
| Grain | 2806 | 59.04 | 368.99 | 115.89 | 180.99 | 1785.46 | 201.75 | 297.44 | 297.44 | 130.48 | 2653.07 |
| Total per period | | 282.88 | 1768.01 | 280.73 | 1015.45 | 4609.11 | 2983.55 | 966.20 | 1387.27 | 1755.83 | 10,656.84 |
| Per day | | 13.47 | 84.19 | 13.37 | 48.35 | 219.48 | 142.07 | 46.01 | 66.06 | 83.61 | 507.47 |

Excretion of nutrients

| | Voided corrected gms. | Nitrogen gms. | N calc'd as Protein gms. | Ether extract gms. | Ash gms. | N. F. extract gms. | Crude fiber gms. | Hemi cellulose calc'd as dextrose gms. | Pentosans gms. | Alpha cellulose gms. | Dry matter gms. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Feces | 4562 | 87.96 | 549.72 | 132.75 | 479.01 | 1251.81 | 1833.01 | 524.17 | 687.95 | 864.96 | 4246.31 |
| Urine | 20,642 | 138.38 | 864.90 | | | | | | | | |
| Total per period | | 226.34 | 1414.62 | 132.75 | 479.01 | 1251.81 | 1833.01 | 524.17 | 687.95 | 864.96 | 4246.31 |
| Per day | | 10.78 | 67.36 | 6.32 | 22.81 | 59.61 | 87.29 | 24.96 | 32.76 | 41.19 | 202.21 |
| Grams digested | | | 1218.29 | 147.98 | | 3357.30 | 1150.54 | 442.03 | 699.32 | 890.87 | 6410.53 |

TABLE 9. *Feeds and Excreta of Goat 4 for Period II (21 Days).*

Percentage Composition of feeds and excreta

| | Pct. $H_2O$ | Pct. dry matter | Pct. protein | Pct. ether extract | Pct. ash | Pct. N. F. extract | Pct. crude fiber | Pct. hemi cellulose calc'd as dextrose | Pct. pentosan | Pct. alpha cellulose | Amounts fed or voided gms. | Amts. fed or voided as analyzed gms. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Hay | 6.29 | 93.71 | 16.38 | 1.93 | 9.77 | 33.06 | 32.57 | 7.83 | 12.76 | 19.03 | 8925 | 8541 |
| Grain | 5.45 | 94.55 | 13.15 | 4.13 | 6.45 | 63.63 | 7.19 | 10.60 | 10.60 | 4.65 | 3150 | 2806 |
| Feces | 10.00 | 90.00 | 11.31 | 2.26 | 9.42 | 24.06 | 42.95 | 11.55 | 15.36 | 19.85 | 4519 | 4519 |
| Urine | | | 5.37 | | | | | | | | 16,504 | 16,504 |

Intake of nutrients

| | Feed corrected gms. | Nitrogen gms. | Protein gms. | Ether extract gms. | Ash gms. | N. F. extract gms. | Crude fiber gms. | Hemi cellulose calc'd as dextrose gms. | Pentosans gms. | Alpha cellulose gms. | Dry matter gms. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Hay | 8541 | 223.84 | 1399.02 | 164.84 | 834.46 | 2823.65 | 2781.80 | 668.76 | 1089.83 | 1625.35 | 8003.77 |
| Grain | 2806 | 59.04 | 368.99 | 115.89 | 180.99 | 1785.46 | 201.75 | 297.44 | 297.44 | 130.48 | 2653.07 |
| Total per period | | 282.88 | 1768.01 | 280.73 | 1015.45 | 4609.11 | 2983.55 | 966.20 | 1387.27 | 1755.83 | 10,656.84 |
| Per day | | 13.47 | 84.19 | 13.37 | 48.35 | 219.48 | 142.07 | 46.01 | 66.06 | 83.61 | 507.47 |

Excretion of nutrients

| | Voided corrected gms. | Nitrogen gms. | N calc'd as Protein gms. | Ether extract gms. | Ash gms. | N. F. extract gms. | Crude fiber gms. | Hemi cellulose calc'd as dextrose gms. | Pentosans gms. | Alpha cellulose gms. | Dry matter gms. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Feces | 4519 | 81.78 | 511.10 | 102.12 | 425.69 | 1087.27 | 1940.91 | 521.94 | 694.11 | 897.02 | 4067.10 |
| Urine | 16,504 | 141.80 | 886.26 | | | | | | | | |
| Total per period | | 223.58 | 1397.36 | 102.12 | 425.69 | 1087.27 | 1940.91 | 521.94 | 694.11 | 897.02 | 4067.10 |
| Per day | | 10.65 | 66.54 | 4.86 | 20.27 | 51.77 | 92.42 | 24.85 | 33.05 | 42.72 | 193.67 |
| Grams digested | | | 1256.91 | 178.61 | | 3521.84 | 1042.64 | 444.26 | 693.16 | 858.81 | 6589.74 |

Table 10. *Summary.*

| | | | Coefficients of Digestibility | | | | | | | | Excretion of Nitrogen | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Presence or absence of infusoria | Goat No. | Period No. | Protein | Ether extract | N. F. extract | Crude fiber | Hemi cellulose | Pento-san | Alpha cellulose | Total dry matter | Pct. of excreted N. voided in feces | Pct. of excreted N. voided in urine | Daily N. balance = gms. of N. stored daily | Nutri-tive ratio of rations | Av. wt. of goat during period lbs. | Net gain or loss during period lbs. | Length of period days |
| Absent | | I | 68.07 | 68.78 | 74.81 | 35.32 | 44.42 | 48.74 | 45.25 | 62.08 | 40.32 | 59.68 | +1.79 | 1:4.2 | 37.00 | +3.0 | 14 |
| | 1 | | | | | | | | | | | | | | | | |
| Present | | II | 71.10 | 67.82 | 76.15 | 40.73 | 50.27 | 50.57 | 51.32 | 63.56 | 36.67 | 63.33 | +2.21 | 1:4.1 | 38.00 | 0.0 | 14 |
| Increase or decrease with infusoria present | | | +3.03 | —3.99 | +1.34 | +5.41 | +5.85 | +1.83 | +6.07 | +1.48 | | | +0.42 | | | | |
| Absent | | I | 67.13 | 54.92 | 74.87 | 37.29 | 46.29 | 49.98 | 48.43 | 60.84 | 57.37 | 42.63 | +4.84 | 1:4.2 | 34.50 | +0.75 | 14 |
| | 2 | | | | | | | | | | | | | | | | |
| Present | | II | 68.78 | 52.94 | 76.58 | 38.17 | 48.49 | 49.92 | 49.99 | 62.03 | 46.35 | 53.65 | +3.70 | 1:4.2 | 36.25 | —2.00 | 14 |
| Increase or decrease with infusoria present | | | +1.65 | —1.98 | +1.71 | +0.88 | +2.20 | —0.06 | +1.56 | +1.19 | | | —1.14 | | | | |
| Absent | | I | 67.36 | 56.58 | 76.40 | 39.16 | 48.48 | 51.79 | 52.55 | 61.61 | 35.36 | 64.64 | +0.93 | 1:4.7 | 59.25 | —2.25 | 21 |
| | 3 | | | | | | | | | | | | | | | | |
| Present | | II | 68.94 | 59.77 | 75.29 | 39.03 | 47.29 | 50.19 | 52.51 | 61.39 | 32.05 | 67.95 | +0.37 | 1:4.6 | 58.00 | +2.00 | 21 |
| Increase or decrease with infusoria present | | | +1.58 | +3.19 | —1.11 | —0.13 | —1.19 | —1.60 | —0.04 | —0.22 | | | —0.56 | | | | |
| Absent | | I | 68.91 | 52.71 | 72.84 | 38.56 | 45.75 | 50.41 | 50.74 | 60.15 | 38.86 | 61.14 | +2.69 | 1:4.0 | 86.00 | +1.00 | 21 |
| | 4 | | | | | | | | | | | | | | | | |
| Present | | II | 71.09 | 63.62 | 76.41 | 34.95 | 45.98 | 49.97 | 48.91 | 61.84 | 36.58 | 63.42 | +2.82 | 1:4.0 | 83.00 | —1.00 | 21 |
| Increase or decrease with infusoria present | | | +2.18 | +10.91 | +3.57 | —3.61 | +0.23 | —0.44 | —1.83 | +1.69 | | | +0.13 | | | | |
| Average figures with infusoria absent | | | 67.87 | 58.25 | 74.73 | 37.58 | 46.23 | 50.23 | 49.24 | 61.17 | | | | | | | |
| Average figures with infusoria present | | | 69.98 | 61.04 | 76.11 | 38.22 | 48.01 | 50.16 | 50.68 | 62.21 | | | | | | | |
| Average of all figures | | | 68.92 | 59.64 | 75.42 | 37.90 | 47.12 | 50.20 | 49.96 | 61.69 | | | | | | | |
| Median figure with infusoria absent | | | 68.02 | 60.75 | 74.62 | 37.24 | 46.45 | 50.27 | 48.90 | 61.12 | | | | | | | |
| Median figure with infusoria present | | | 69.94 | 60.38 | 75.94 | 37.84 | 49.13 | 50.25 | 50.71 | 62.48 | | | | | | | |
| Median of all figures | | | 69.12 | 60.75 | 74.71 | 37.84 | 47.35 | 50.27 | 48.90 | 61.86 | | | | | | | |

# THE PIGEON FLY AND PIGEON MALARIA IN IOWA

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During the past summer, 1929, pigeon fanciers and commercial squab isers in Iowa and several southern states have been much concerned by e presence of a parasitic fly which greatly worried and annoyed their rds. As the summer advanced, the flies kept increasing in numbers and e pigeons became increasingly disturbed and restless. The colder weather is fall, however, has checked reproduction and the flies have been slowly iecreasing. Although at the present time (December) the flies are fairly common on the pigeons, apparently no purparia have been deposited in the nests and cotes since the latter part of October. Puparia, collected during September and kept in containers in the pigeon houses, are still viable and apparently normal. Further experiments are being carried on to determine whether or not the flies and puparia will survive the winter weather of Iowa, and if the flies survive, whether or not they will continue to breed and deposit puparia during the winter.

The pigeon fly, *Pseudolynchia maura* (Bigot), was first reported from Ames, Iowa, by Knab in 1916. He also recorded the insect from Key West, Florida, and Savannah, Georgia. The latter seems to be the earliest published record of its occurrence in North America, the specimens being taken on pigeons at Savannah, Sept. 28, 1896, by W. Duncan. Bequaert (1925) and Bishopp (1929) have published notes and records of the pigeon fly from Florida, Georgia, South Carolina, Alabama, Louisiana, Texas, Arkansas, southern California and a number of foreign countries. The numerous records from southern Europe, Africa, Asia Minor, Philippine Islands, India, Hawaii, West Indies, South America, North America, and various other regions illustrate how the relationship of a host and its close parasite, both of them alternate hosts to the organisms of a blood disease, may be the main factor in the spread of such a disease into country after country. In this case the importation of pigeons infested with pigeon flies and both bird and fly infected with malarial organism has carried the disease into North America. The Iowa infestation resulted from such shipments from Florida. After studying an extensive series of the fly from many parts of the world, Bequaert was inclined to believe that *P. maura* was originally an old world insect, which was introduced by man into the Americas, together with the domestic pigeon.

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The pigeon fly (Pl. I, *a*) is a strange-looking, highly specialized parasite belonging to the dipterous family Hippoboscidae. Its body is strongly flattened, leathery, brownish in color and provided with large legs and long, slender wings. The powerful legs and other special adaptations enable the parasite to crawl rapidly about on the body or through the feathers of its host, or to take sudden flight when the bird is handled. The tarsal claws (Pl. I, *c*) are also large, strongly bent and provided with long teeth, thus enabling the fly to cling tightly to the feathers. As a result it is quite difficult for the pigeon itself to dislodge the fly. On its host or elsewhere the fly is always on the alert and capable of moving quickly, generally running sideways in a somewhat crab-like manner. This mode of locomotion is quite similar to that of other species of hippoboscids found upon a number of our native species of wild birds.

*Pseudolynchia maura,* like other members of the family, is a bloodsucker and not capable of living off of its host for any considerable period of time. Its feeding habits and movements greatly annoy and provoke much worry and irritation among the squabs, fledglings and older birds. Heavily infested pigeons frequently spend no small part of their time fighting the flies by pecking and thrusting their beaks among their feathers. This pecking causes injury and deterioration in the general appearance and quality of the feathers, both of which are of commercial importance to raisers of fancy and breeding birds. In addition to the injury and annoyance caused directly by its feeding and irritating movements on the bird, the fly also serves as an intermediate host and is known to transmit two disease-producing protozoa of the common pigeon (*Columba livia*). An outbreak of one of these diseases, pigeon malaria, was found in Iowa during the past summer.

An examination of preparations of both fresh and dried stained films of blood from pigeons infested by *Pseudolynchia maura* (Bigot) showed the presence of a haemoproteid parasite, *Haemoproteus columbae* Celli and Sanfelice (1891), in large numbers. This halteridium is the causative organism of a disease of the pigeon, called pigeon malaria, which has been known in India, Africa, Europe (southern part), and South America for many years. Doctors Edw. and Et. Sargent first convicted the pigeon fly of carrying and transmitting pigeon malaria in 1906. Since then, a considerable amount of work has been done upon the ethology and morphology of *Haemoproteus columbae* (Pl. II) in the pigeon (asexual cycle) and in the pigeon fly (sexual cycle) by Aragao, Negri, Acton and Knowles, Adie, Gonder, Wenyon, and others, but not much attention has been given to the biology and control of the intermediate host, the pigeon fly, which acts as a biological carrier of the disease from pigeon to pigeon. Although the other species of a protozoan, *Trypanasoma hunnai* Pitagula (1904), was not found in Iowa, further examination of fresh and dried stained smears of blood from infested pigeons in the southern states may also show the presence of this parasite in the United States. Aragao (1927) has reported the presence of this trypansome both in the pigeon fly and pigeons in Brazil, South America.

In collecting several hundred pigeon flies upon unfledged and older pigeons, many of the flies settled upon the exposed skin and clothing of the writers, but in no instance did they bite. When the birds are handled, the flies taking wing do not, as a rule, wander very far away, and before returning and concealing themselves on their hosts, they generally perch for a few moments upon nearby objects. The pigeon fly is practically a permanent parasite and spends almost all of its existence as a fly upon its host. It was difficult to determine whether the disturbance of the birds was due largely to the feeding habits of the flies, or to the tickling and mechanical irritation resulting from the crawling and other activities of the flies upon the pigeons. Nevertheless, their mode of life is exceedingly irritating and causes marked restlessness and worry to the birds.

Observations indicate that the pigeon fly seldom leaves or flies away from its host under normal conditions, except for certain special purposes as when forced to establish new quarters due to the death of its host or when a parturient female seeks a favorable place to deposit a mature larva. Ordinarily, the flies make little use of their wings. If, however, the birds are caught and the feathers parted and ruffled to locate the flies, many of the disturbed individuals make very short, quick flights and frequently settle upon the nest boxes, walls, or other objects. On the other hand, the pecking at the flies or the ruffling of the feathers by the bird itself rarely results in the flies taking flight.

Within a few minutes after being captured and placed in glass vials a number of female flies gave birth, one at a time, to full-grown larvae, which began to transform into the resting stage immediately after deposition. At the time of extrusion the mature larva is enclosed in an obovoid capsule and pupal case, it is incapable of locomotion, and is whitish in color with a black cap-like structure at the caudal end. As the transformation continues, the puparium (Pl. I, *d*) successively turns from white through yellow, orange, light to dark brown, and in the course of two to three hours becomes strongly indurated, somewhat shiny and jet black in color.

A number of the nests in the infested pigeon houses were equipped with false sliding bottoms to facilitate cleaning. On the floors under the false bottoms of 60 nests, 255 puparia were collected in about two hours. Sometimes, as many as 10 puparia were found beneath a single false bottom. The puparia were much more difficult to find in the nests without the false bottoms. In the latter they were more or less concealed in the dust, chaff, stems, and faecal matter. Several infested pigeons for experimental purposes were confined in small boxes having the water and food pans attached to one side and almost resting on the floor. In these cages a large percentage of the puparia were deposited on the floor beneath the pans. These and other records indicate that the female flies frequently consign the puparia to a less or more protected situation for the developmental period.

Several puparia, deposited in glass vials during the latter part of September, required 35 days for the transformation of the pupal stage. In Africa, Bedford (1924) states that the pupal stage lasts from 23 to 28 days. In the southern part of the United States, Bishopp (1929) reports the resting stage to last for 20 to 30 days. No records of this stage have been secured for the summer season in Iowa. Soon after a fly emerges, it is ready for a meal of the pigeon's blood, which is absolutely essential for the life of the fly.

The adult fly remains almost constantly upon the pigeon and is not known to feed upon other domesticated birds and fowls or wild birds in America. Its mouthparts are highly developed for sucking blood and feeding takes place only in the adult stage.

Experiments for the control of the pigeon fly were conducted at Clinton and Ames, Iowa, during the latter part of the past summer, 1929. These consisted of cleaning up measures to destroy the puparia and some preliminary tests with certain insecticides used in the form of dusts, dips, sprays, and paints. As the resting stage is passed largely in the nests and lasts from 20 to 35 days, the infestation may be greatly reduced by carefully cleaning out and destroying the nesting materials as frequently as possible, preferably every 20 days. Bishopp also found that a light application of a commercial household fly spray (kerosene-pyrethrum extract) upon the nests and birds destroyed many of the flies. These sprays should be applied very lightly, with a good atomizer.

Pyrethrum and derris powders were used both as dusts and as dips. In the dust form the powders were sifted quite liberally among the feathers of the birds. The pyrethrum dip consisted of five ounces of the powder added to five gallons of rain or soft water in which two and a half ounces of laundry soap had been dissolved. The derris dip was prepared in a similar manner.

Nicotine sulfate was used both as a nest paint and as a dip. The walls of a few nests were painted with nicotine sulfate (40%) in the evening, and the following morning the pigeons were caught and examined for pigeon flies. In addition, several pairs of birds were confined for one night in small boxes having the walls freshly painted with nicotine sulfate and the open side closed with a wire screen for ventilation. After a period of from 12 to 16 hours a number of flies were found dead in the nests and upon the floor of the cages, but it was not difficult to find living flies on the birds. The nicotine fumes seemed to have some deleterious effect upon the pigeons, especially the young birds in the nest, but no birds were seriously injured or killed in the experiments. In the form of a dip, nicotine sulfate was used at the rate of one ounce in six gallons of soft water containing four ounces of dissolved laundry soap. The results secured with the nicotine dip were quite satisfactory.

Pyrethrin-soap as prepared by Van Leeuwen (1926) and modified by Van Leeuwen and Van Meuden (1927) of the U. S. Bureau of Entomology, proved satisfactory as a dip for the control of pigeon flies. This formula consists of 86.5 ounces of sodium oleate, 9.5 ounces of the alcoholic extract of pyrethrum flowers, and 6 fluid ounces of sodium silicate. This material is manufactured and sold commercially under the trade name "Red Arrow." It is non-poisonous and was used as a dip at the rate of one ounce of the commercial concentrate in six gallons of soft water. After carefully cleaning out and disposing of all manure, dirt, and nesting materials so as to insure the death of the puparia, the walls, floors, nests and outdoor yards were thoroughly sprayed with waste crank case oil. The cleaning and spraying operations, coupled with the dipping of all pigeons in the pyrethrin-soap dip, completely eradicated the flies on one of the larger pigeon farms of the state. On this farm over two thousand pigeons were dipped on warm, sunny days during the first part of October without the loss, or even apparent injury, of a single bird. In some of the preliminary tests a number of pairs of fancy birds were dipped in pyrethrin-soap solution and the following day the pigeons were placed in shipping crates and sent to other bird fanciers. No apparent injury to the birds was observed by the pigeon fanciers.

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PLATE I.

Pigeon Fly, *Pseudolynchia maura* (Bigot); *a*, dorsal aspect of male; *b*, fringe at postero-lateral angle of scutellum; *c*, posterior tarsus; *d*, puparium of pigeon fly.

PLATE I.

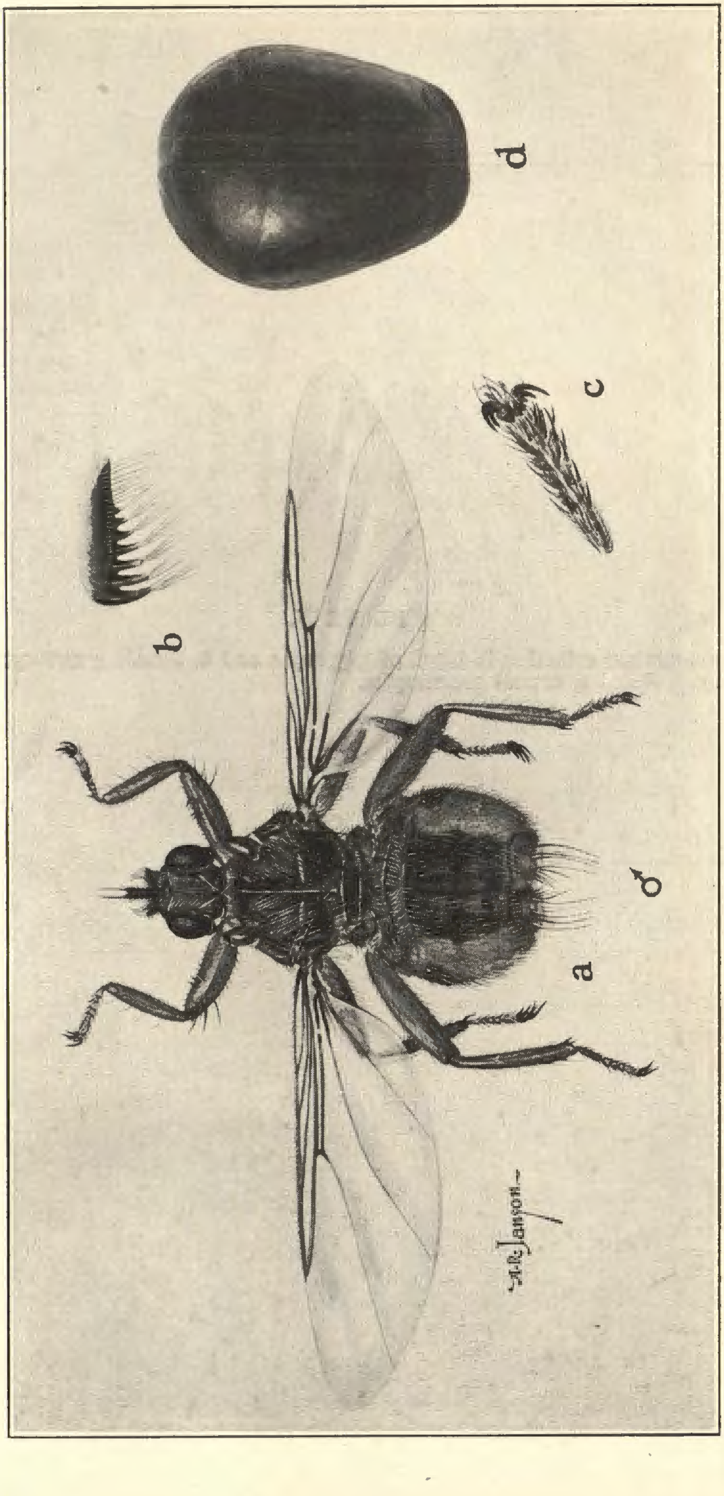
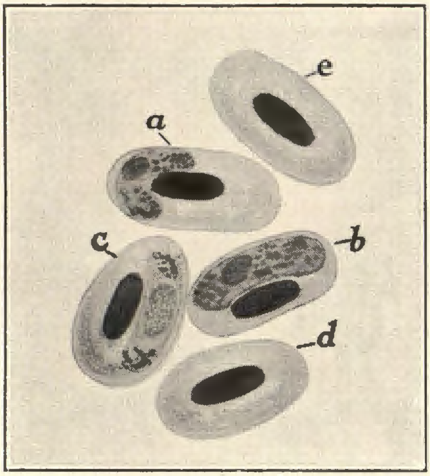


PLATE II.

*Haemoproteus columbae* in blood of pigeon; *a* and *b*, female gametocyte; *c*, male gametocyte; *d* and *e*, normal gametocytes.

PLATE II.



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